Vol. XXIII, No. 7
NOVEMBER 1956

THE SCIENCE TEACHER

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JOURNAL OF THE NATIONAL SCIENCE TEACHERS ASSOCIATION

UNIVERSITY OF WISCONSIN PHOTOGRAPHIC LABORATORY

THIS MONTH'S COVER . . . highlights the "historic" theme of this month's issue. It is a photographic reproduction of one of the many paintings which David Teniers, the Younger, executed in the 17th Century on one of his favorite subjects: The Alchemist in His Laboratory. A particularly interesting point about this painting is that the figure at the far right is believed to be a self-portrait of the artist.

The photograph was submitted by Aaron J. Ihde with his article, "The Development of Scientific Laboratories," which begins on page 325 of this issue. Dr. Ihde's article goes back as far as the 16th Century. Slightly more "modern" is C. A. Ronan's biographical report on "The Halley Tercentenary," on page 355. And to bridge the gap between the past and the present, the background of several other features in this issue, there is the lead article by Sidney Rosen on "A Century of High-School Science." It starts on page 321.

Readers' Column

The article by Dr. John R. Smeltz, "Retention of Learnings in High School Chemistry," in the October 1956 issue of *The Science Teacher,* contains the first printed evidence I have seen that supports my long-time contention on the proper sequence of high school physical science courses. On the basis of our experience here at Springfield High School, where we have a high percentage of college entrants and a sizable number of scholarship and prize winners, I believe that the prevalent method is wrong.

Dr. Smeltz concluded that "pupils enrolled in physics retained more chemistry than pupils not enrolled in physics." This supports my conviction that high school chemistry should be introduced into the curriculum at the fourth or senior year level and *following* the course in physics. A superficial survey of high school programs throughout the United States shows that, in general, chemistry is offered in the third or junior year level and *is followed by* the course in physics.

I have certain basic reasons for my belief. For one, historically chemistry developed after mathematics and physics; if this was the experience of the human race, it follows that it should be the experience of pupils entering those sciences. Another point I make is that chemistry is a highly imaginative science whereas physics, as commonly taught in our secondary schools, is less imaginative. Without previous science work, the beginning student is confronted in chemistry with a situation that may overwhelm him.

CARROL C. HALL
Springfield High School
Springfield, Illinois

(Editor's note: The following letter was received at NSTA headquarters late last May and was inadvertently overlooked for publication in an earlier fall issue of The Science Teacher. *Because of its human interest outlook on the teacher-student relationship, we believe it warrants this delayed publication. An accompanying letter from Francis W. Tremblay, Principal of Warm Springs Elementary School, reported that "Mr. Meshwert has signed a contract with the Mt. Eden School District near Hayward for the fall term due to the fact that we are a small school and have no vacancies this year." Mr. Meshwert was a student teacher at Warm Springs under the direction of San Jose State College.)*

The eighth-grade class of the Warm Springs Elementary School would like to purchase a membership in your organization for our student teacher, Mr. (Wilbur "Bill") Meshwert. We are going to present him with the membership card at our graduation ceremony.

The reason why we have decided on this gift is the fact that Mr. Meshwert has made science so interesting for us that we would like to encourage him still further. Perhaps, as scientists, you would be interested in some of the things we have been doing. We first studied about seashore life and went on a trip to Half Moon Bay, where we collected sea animals. Then we had units on electricity and weather. We built our own weather station and kept graphs on the daily changes in temperature, humidity, and air pressure. Right now we are studying about light. We have built our own telescope and periscope and are going to build many other interesting things from our optical kit.

ALBERT ESPINOZA, *Class President*
LEON GIBSON, *Student Body President*
Warm Springs Elementary School
Warm Springs, California

THE SCIENCE TEACHER

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MEMBERSHIP

The membership year coincides with the calendar year. New entries during the fall months extend through the following calendar year. Library and elementary school subscriptions coincide with the school year or run for one year from date of entry.

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(payable in annual installments of $10.00)

* Includes the *Elementary School Science Bulletin* in quantity lots.

Coming . . .

in the December issue of *The Science Teacher*

- The Science Teaching Improvement Program (AAAS)
- Report of the New York City Board of Education Advisory Committee on Science Manpower
- Report on the 1956 Wisconsin Conference for High School Chemistry Teachers

Editor's Column

This month we have really gone "historic"—partly by design and partly by chance. NSTA's committee cooperating with the NEA Centennial Action Program is responsible for procuring Dr. Rosen's delightful romp through 100 years of history of high school science. Read it, enjoy it, and let the committee know how you like it. We have been promised a similar piece reviewing the history of elementary school science for early publication.

Anyone who'd like to "dip into the future" and look backward from the year 2057 is eagerly invited to write us an article on science teaching in those 100 years. Put your imaginations to work; the editors will offer a prize or prizes for the best manuscripts.

Added perspective for the role of the laboratory in science teaching today is provided by Dr. Ihde's review of laboratory teaching in chemistry. Some 200 summer conference attendants enjoyed this paper when it was presented at Madison, Wisconsin, in 1955. We're happy to add it to the literature of science education via *TST* publication.

For historic literature on NEA, we suggest "Yesterday at NEA," a 32-page illustrated booklet published by NEA's National School Public Relations Association for the NEA Centennial. Single copies are 25¢; quantity orders are less. You can order it from NEA, 1201 Sixteenth St., N.W., Washington 6, D. C.

More recent history is Stan Brown's report of the entries and judging procedures used last year in Region VII of the Science Achievement Awards program. Similar reports could be given for all the regions. And come next March 20 or so, eight teams of judges will again be reviewing several thousand reports of student projects in science. Perhaps 2000 students will receive honors and encouragement in the form of U. S. Bonds, gold FSA pins, and FSA certificates. How many of *your* students will be among them?

Many science teachers have asked us how they can secure a Fellowship or stipend enabling them to attend a conference or institute next summer. It is still too early to apply, but we can report that as many as 100 such programs are scheduled and they will provide financial aid for up to 5000 science teachers. NSTA through its Future Scientists of America Foundation will conduct at least three such conferences. Summer programs with industrial sponsorship from such as General Electric, Westinghouse, du Pont, and Shell are already being planned. And the federal government through the National Science Foundation will provide grants enabling summer institutes to be held at 75 to 80 colleges and universities. NSTA will continue its efforts to catalyze summer employment of teachers in science-related jobs and as research assistants.

The best way to get details on what is offered and how to apply is to read the February 1957 issue of *TST*. Be sure, too, that you are on NSTA's mailing list.

Robert H. Carleton

THE SCIENCE TEACHER

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The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

A Century of HIGH-SCHOOL *Science*

By SIDNEY ROSEN

Assistant Professor of Physical Science, Brandeis University, Waltham, Massachusetts

IN THE YEAR that the National Education Association was born (1857), there were probably less than 300 free public high schools in the entire United States. Most of these schools offered a number of science courses ranging from natural philosophy (or physics) and chemistry to dialling and gauging, now archaic techniques of measuring. Geography, astronomy, geology, botany, physiology, zoology, navigation, and surveying were also taught in the early years of the high school. Of these subjects, however, only physics, chemistry, and general biology remained to dominate the high-school curriculum.

Until after the Civil War, science was taught primarily out of textbooks to high school pupils. Elbridge Smith, first headmaster of the Cambridge, Massachusetts, English High School, recalled that when the school opened in 1847, "... in science, the instruction was wholly by catechism. There were illustrative diagrams in the textbook which might, or might not, be transferred to the blackboard ... not a single piece of apparatus or a book of reference, except the Bible and possibly a dictionary."

In all scientific areas, textbooks were written so that anyone could teach science regardless of background and preparation. Lesson I of Asa Smith's *Illustrated Astronomy,* published in Boston in 1866 and heartily endorsed by the great American astronomer, Simon Newcomb, began:

"*Question.* What is the body called upon which we live?

"*Answer.* It is called the EARTH, or WORLD." and went on in this vein to bring every known astronomical fact before student and teacher.

Early activities in the high school were marked by the personal interest and participation of famous university professors. In 1840, Professor Alexander Dallas Bache (grandson of Benjamin Franklin), then president-elect of Girard College in Philadelphia, volunteered to act as principal of the Central High School without compensation. In Cambridge, Massachusetts, Professor Louis Agassiz of Harvard University lectured on natural history to students at the Cambridge High School every week during the school year of 1848; in 1851, he gave a series of public lectures, the proceeds of which ($175.50) were used to establish a cabinet of Natural History at the high school. In some large city systems, human physiology and anatomy was taught by a doctor of medicine. In 1870, Dr. J. F. Holt of the Central High School in Philadelphia spent $500 of the school budget for large wax models of parts of the human anatomy.

Most of the innovations in high-school science teaching began in New England, particularly in Massachusetts. These new ideas and attitudes spread westward rapidly, and in some cases were improved upon in high schools west of the Alleghenies. In 1857, the Massachusetts legislature passed an act requiring the teaching of natural philosophy, chemistry, and botany in high schools located in towns of 4000 population and over, the first legislation of its kind. How well this law was enforced is impossible to know; the catechetical method of teaching undoubtedly helped headmasters keep such courses in their schools.

Illinois followed suit in 1872 by making physics, physiology, botany, and zoology mandatory for the high-school curriculum, a law which came on the heels of previous legislation which required that all applicants for teacher certification be examined and found satisfactory in chemistry, physiology, botany, and zoology. One problem that arose at once was: who was to examine the examiner? There is an anecdote about a lady being quizzed by an Illinois school superintendent who asked her to what class the turtle belonged. "It's a crustacean," she answered, probably thinking that the turtle was

like a pie crust—upper and lower layer, with filling in between.

"No," said the superintendent, "it's a mollusk, because it has a shell!" Nevertheless, the lady got her certificate.

The acquiring of competent science teachers was a serious problem. Though the Normal schools and teachers colleges increased in popularity during the last part of the 19th century, their graduates were actually not competent to teach science at the high-school level. The colleges and universities could not supply sufficient specialized manpower for high-school science teaching (except, perhaps, in zoology, a specialization for which there was little demand in industry at the time). One can imagine the horror instilled in any member of a respectable college science faculty by the two-year science program for students at the New Britain Normal School, Connecticut, in 1894:

First Year

Chemistry	13 weeks	5 recitations per week
Physics	40 weeks	4 recitations per week
Physiology	13 weeks	5 recitations per week
Physical Geography	4 weeks	4 recitations per week

Second Year

Physics	13 weeks	4 recitations per week
Botany	10 weeks	5 recitations per week
Geology	5 weeks	4 recitations per week
Biology and Zoology	10 weeks	4 recitations per week

Teachers colleges attempted to revise their curriculums during the first half of the 20th century to meet the university criteria for competency in science. The attitude persisted, however, that students trained for science in institutions of professional education could be considered neither efficient scientists nor teachers of science. This "cold war" between the liberal arts and teachers colleges still persists today and has helped to widen the gap between the high school and the university.

The catechetical method of teaching high-school science was replaced by what might be called the lecture-demonstration method. At first, special teachers skilled in laboratory techniques were called in to perform experiments before the class. Later, high-school systems attempted to find science teachers who could manipulate apparatus as well as teach by textbook. Demonstration rooms (especially for chemistry) were usually located in basements of schools, for fear of explosions and foul odors (see Figure 1). Collections of botanical, geological, and zoological specimens, called cabinets, were also popular. They furnished, in most high schools, the closest look at the workings of nature a student could get.

The teaching of science in the high schools was given a great general impetus after the Civil War by certain changes in the national milieu. The pragmatic "scientism" of Herbert Spencer appealed to Americans: science could provide all the answers to all the problems of mankind and make a better world. The Morrill Act of 1862 fostered the creation of many new colleges and universities where the emphasis was laid on practical science. By this action, Congress not only opened a door to higher education for graduates of the non-classical courses in high schools, but also caused the high-school science curriculum to be stressed.

About this time, there appeared a trend toward the use of college research methods in the teaching of high-school science. The German universities of the mid-19th century had inspired most of the young Americans who had gone to do graduate work in them to believe in a new concept: the specialist. He was the scholar who searched for truth by using the seminar, the specialized library,

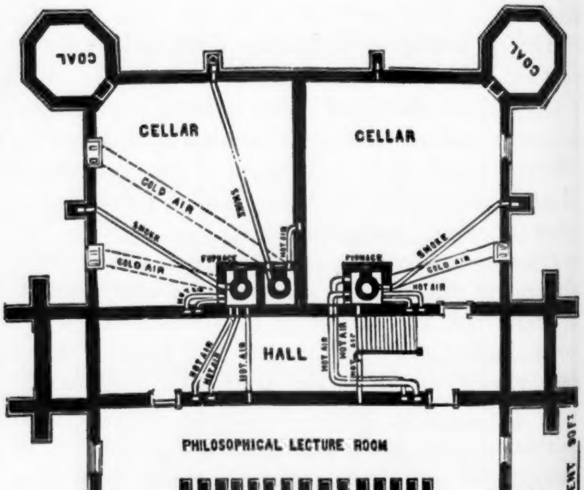

Figure 1. This is the basement plan of the St. Louis Public High School (1872). The administration was very proud of the tower apparatus rooms with "sinks and water, and two fireplaces at each end of the lecture room for experiments in chemistry and philosophy."

the periodical, the monograph, and the laboratory. At the same time, there was a movement in European secondary schools to teach students to do things with their hands. Exhibitions of student woodwork, bookbinding, and copperwork at the Philadelphia Exposition of 1876 excited American educators. President John D. Runkle of the Massachusetts Institute of Technology immediately made a required course in the use of tools part of the Institute curriculum. In the common school system, this exhibition stimulated the inception of "manual training" courses.

It was inevitable then that the dual concepts of painstaking laboratory research and using one's own hands to learn should lead to the idea of individual laboratory work in high-school science courses. Such a movement began first in chemistry, the first high-school chemistry laboratory being opened at the Girls High and Normal School in Boston in 1865. It is amusing to note that educators of that period believed that chemistry and botany were the two sciences ideal for the education of females. In 1871, the principal of the Dorchester, Massachusetts, High School reported enthusiastically that in his chemistry laboratory, ". . . the girl who has rightly improved her opportunities in the laboratory may go to the higher responsibilities of domestic life and redeem all the endeavors of home from the rule of ignorance . . . Great as have been the triumphs of chemistry in general, and in industrial science, there remain for it yet higher triumphs in the nursery, in the kitchen, in the parlor; and the time is not far distant when the same fingers that enchanted us by the same music which they make from the guitar or the keyboard of the piano, will also manipulate with equal skill the test tube, the beaker, and the retort." Contrarily, the New Bedford, Massachusetts, School Board decided in 1887 to exclude girls from the high school physics laboratory, since the female mind, in general, was not so constituted as to apprehend the philosophy of physics!

The first high-school physics laboratory was opened in 1880 at the Boston English High School by Dr. Alfred Payson Gage. With a flair for predicting trends, Gage soon left teaching to achieve fame and fortune in the scientific apparatus business. But the opening move for the high-school laboratory had been made. Only the final stamp of approval by the university was lacking. This came in 1886, when Harvard University officially accepted high-school laboratory physics for admission to the A. B. degree course.

A pamphlet containing a list of 40 acceptable experiments was published by Harvard and sent out to secondary schools. The student had to come to the University to be examined in the physics laboratory and also had to present a laboratory notebook containing write-ups of the performed experiments and signed by his high-school teacher. The professor in charge of this program was the well-known physicist, Edwin H. Hall (of the "Hall effect"). Harvard's bold action set off a minor boom in the installation of physics laboratories in schools that specialized in preparing students for the University. Inevitably, high-school science teaching changed from textbook to laboratory methods. In many cases, recitations and lectures were abandoned in favor of more time spent in the laboratory. With the characteristic American optimism for educational panaceas, the high-school science laboratory was hailed as the place from which pupils would go out "able to see and to do."

Dr. Johnson's Charts

The cost of equipping a high school with laboratories was high, and at first only large city school systems could afford such a luxury. In 1876, Boston spent $8465 on "philosophical, chemical, and mathematical apparatus!" But for most rural schools, laboratory equipment existed only as a teacher's daydream, and teachers usually had to be satisfied with a set of Dr. Johnson's Substitute for Physical Apparatus, ". . . consisting of indestructible charts, comprising 500 diagrams which represent over $6000 worth of apparatus, illustrating the principles of natural philosophy and astronomy . . . designed as a complete cheap and durable substitute for the expensive philosophical apparatus in the Common Schools and Academies. Set for $15—10 charts." (See Figure 2.)

Other areas in the sciences fell heir to what some called "this laboratory madness." Laboratory work was attempted in physical geography, botany, physiology, and zoology. In all cases, as in physics and chemistry, the high-school laboratory course copied the college elementary science course, with its accent on research techniques.

In the twentieth century came the sudden tremendous increase in the number of high schools, coupled with the realization that for most pupils the high school had become a terminal education. The notion that high-school science courses ought to mimic specialized college courses was attacked by educators; *viz.*, the views of John Woodhull of Columbia University in 1907 on the state of high-school physics: "These college students have a starvation course in measurement called physics.

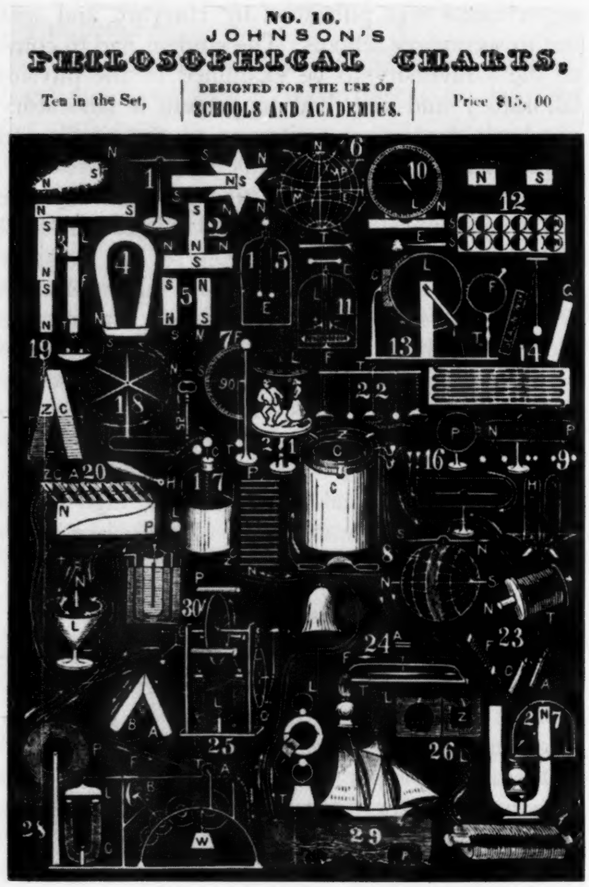

Figure 2. Here is one of Dr. Johnson's Charts, illustrating electromagnetic apparatus. Charts during this period were often printed black on white to simulate chalk on a blackboard.

Their tutors . . . are suspicious of that expansive thing called culture . . . They surpass the theologians in narrowing down their lines of orthodoxy . . . The influence of the college is driving culture . . . out of the schools."

By 1920, most high-school physics and chemistry laboratory courses had crystallized into a formal pattern designed primarily for college preparatory students. In order to satisfy the needs of the terminal, or vocational, student, courses were fashioned which dealt with the practical applications of chemistry or physics. Such courses approached the subjects in an entirely qualitative manner—a direct contrast to the quantitative methods for which college professors had fought.

Physical geography virtually disappeared from the field as a high-school science by 1920. All attempts to teach the subject as a laboratory science seem to have eventually failed; by this date, only a few Midwestern high schools were offering laboratory geography. Botany, zoology, and physiology all passed down the path to oblivion in the high school; their place was taken by general biology, a course designed by high-school teachers and first taught in New York City in 1909.

Human physiology, a course once important in the high-school curriculum, was sabotaged by the WCTU's drive for temperance legislation during the last half of the 19th century. Such laws, passed eventually by most of the states and territories, prescribed classroom periods and textbook space for teaching about the dangers of alcohol, tobacco, and narcotics in physiology courses from the third grade through the first year of high school. The fanaticism and persistent lobbying of the anti-alcohol ladies inspired one Philadelphia legislator to create this prosody in 1885: "But now, Annus Domini, eighty-five,/ Blessed Woman evolves a plan/ By which she eventually hopes to secure/ The absolute control of man./ On his wines and beer, tobacco and cigars,/ She will place a permanent lien;/ By teaching the boys and girls to shout:/ Physiology and Hygiene!"

The famous Committee of Ten, organized by the NEA in 1891, was the first group to attempt to revise high-school science on a nationwide scale. But by 1913, it was apparent that no panaceas for high-school science teaching had been found. Another committee was set up to reorganize high-school science, and their report, published in 1920, was an admission of the failure of the laboratory method of teaching. Since then, there have been at least three important attempts at analysis and reorganization. Two were reported in the Yearbooks of the National Society for the Study of Education: the 31st (1932) and the 46th (1947); the third appeared in the January 1953 issue of the Bulletin of the National Association of Secondary School Principals.

Nevertheless, after these 100 years of growth and change in high-school science teaching, no satisfactory answers seem to have been found for certain fundamental questions. What knowledge at the high-school level is best for college preparation? Should this knowledge differ for the vocational or business student? Is the laboratory method of teaching really fruitful for the high-school student? Are any useful techniques transferred? What should a high-school science teacher know? Should he be a specialist or a generalist? How can high-school students be motivated to elect physics and chemistry courses?

These questions began to be asked about 75 years ago. The changes wrought in civilization by science and technology since then have made the need for answers particularly urgent today.

THE DEVELOPMENT OF SCIENTIFIC LABORATORIES

By AARON J. IHDE *

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IT is not inappropriate for a chemist to discuss the history of laboratories since *Webster's Collegiate Dictionary* defines "laboratory" as follows:

> 1. originally, the workroom of a chemist, 2. a place devoted to the experimental study of natural science, 3. a place for testing or preparing drugs, chemicals, explosives, etc.

It is interesting to note that two of these definitions are connected with chemistry and that one of them has a preferred position over the traditional idea of a laboratory being a place for the experimental study of natural science.

As we examine the development of chemical thought we find that the laboratory played an important role in the development of alchemy, one of the precursors of modern chemistry. Although the alchemists were proceeding under an erroneous conceptual scheme which led them to believe that they could successfully transmutate metals through the agency of the philosopher's stone, they nevertheless were responsible for the development of chemical apparatus and methods, and gained a knowledge of the properties of such chemical substances as salts, acids, alkalies, and alcohol. They gave us a variety of flasks, retorts, separatory glasses, and funnels, and developed the art of distillation from one which consisted of the collection of condensate from the underside of a cover to one which brought about the concentration of alcohol from dilute solutions by the beginning of the thirteenth century. The three centuries which followed saw distillation brought to a remarkably high state of perfection while certain alchemical vessels which proved to be without value for chemistry were rejected. The majority of vessels proved suitable and while they underwent various modifications as they became specialized for certain purposes, they show a definite resemblance to those used by the earlier workers.

Alchemical laboratories of the sixteenth and seventeenth centuries, which have been the subject of artistic representation, show a resemblance both to the kitchen and the smith's shop.[1] In keeping with alchemical tradition there was perhaps little instruction in these laboratories because alchemy was a secret science and only a few close associates were ever trained to carry on this particular tradition.

It was not until the seventeenth century that the tradition of rapidly publicizing scientific results arose, but from then on scientific progress was rapid. However, students were not brought into the laboratory for practical instruction on a widespread basis until the beginning of the nineteenth century. Laboratory instruction of students was preceded by the tradition of demonstration lectures, harking back in a sense to the anatomy lectures in late medieval universities, but developing a tradition of their own late in the eighteenth century. The lectures in the *Jardin du Roi* in France established a pattern which was developed to a high state in England after the founding of the Royal Institution where Davy's excellent demonstration lectures attracted all segments of society. Berzelius introduced demonstration lectures in Sweden in 1812 and the practice was followed by such renowned teachers as Faraday, Liebig, Woehler, Bunsen, and Hofmann.

In the eighteenth century laboratories were seldom associated with educational institutions but important scientists and teachers used their own homes as laboratories. This was the case with Lavoisier, Priestley, Cavendish, Dalton, and Berzelius. It was only with the development of such technical schools as the *Ecole Polytechnique* in 1795 that scientific instruction began to receive emphasis in the educational curriculum. Even here it is questionable that students received any opportunities for individual laboratory work except for a few exceptional students who might be permitted to do work in their professor's private laboratory. Berzelius in Sweden set up a practice of accepting a promising young scientist into his laboratory each year and in the French schools such workers as Vauquelin, Gay-Lussac, and Thenard provided working space for a few of their students. Regular laboratory instruction as a part of student work was established at the University of Giessen when

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* This article is a condensation of a paper presented at the Science Conference sponsored by the National Science Teachers Association in cooperation with the University of Wisconsin Summer Session, held in Madison June 29 to July 1, 1955.

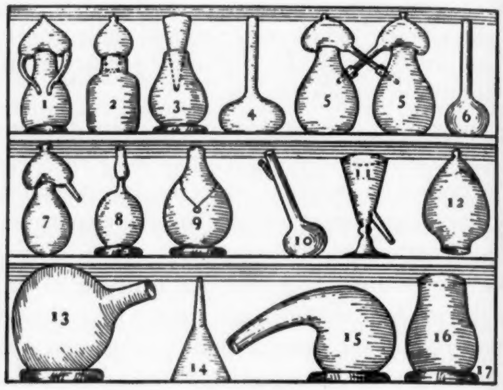
[1] Read, John, *The Alchemist in Life, Literature and Art*. London: T. Nelson and Sons, 1947.

Liebig received his appointment there in 1824. Liebig first introduced his students to the study of qualitative and quantitative analysis, following which they made chemical preparations, and finally completed their degree after some sort of an original investigation.

The Common Legend

There is a common legend that Liebig was the first chemist to offer laboratory instruction. This belief, which was fostered by Liebig himself, is erroneous. Stromeyer, Fuchs, Doebereiner, and N. W. Fischer had all been offering laboratory instruction in German universities, Stromeyer's laboratory at Goettingen dating from 1806.[2] At the Rensselaer Polytechnic Institute in Troy, New York, Amos Eaton had introduced laboratory instruction before 1824,[3] as had Thomas Thomson at Glasgow. Actually, all of these men were belated innovators. Lomonosov in Russia had offered laboratory instruction to students from 1749.[4] However, Lomonosov represents one of those cases of the innovator who is away from the centers of intellectual activity and his laboratory was not imitated elsewhere.

The laboratory of Liebig at Giessen established a pattern for graduate study in science which was quickly imitated by Woehler, Bunsen, Baeyer, Emil Fisher, Ostwald, and numerous others. The pattern was exported to America with students who returned to their homeland after study in the German universities. Imbued with the importance of science, they sought to establish mathematics and natural philosophy in the curriculum of their colleges but found themselves blocked by the hold of the classical curriculum. At first they found it necessary to establish scientific schools as appendages to the universities. The Sheffield Scientific School at Yale was founded in the 1840's by Benjamin Silliman, Sr. in order to introduce more science into the curriculum, and such Liebig students as Eben Horsford and Wolcott Gibbs were instrumental in the founding of the Lawrence Scientific School at Harvard. Laboratory instruction in chemistry developed rapidly in the colleges following the founding of scientific schools and the spread of instructors graduated from these schools. A further stimulus to scientific instruction was given by the passage of the Morrill Acts during the eighteen sixties. These acts encouraged the founding of agricultural and engineering colleges which placed a definite importance on scientific instruction. Before the century had come to a close, laboratory instruction was well established at the undergraduate level and such universities as Harvard, Yale, Johns Hopkins, Pennsylvania, Michigan, and Wisconsin were offering graduate degrees in science.



Apparatus used by the Alchemists

(1) Pelican; (2) vessel for mixing; (3) Hell; (4) flat-bottomed matrass; (5) twins; (6) matrass; (7) alembic in one piece; (8) philosopher's egg; (9) egg within an egg; (10) small matrass; (11) separation glass; (12) blind alembic; (13) recipient; (14) glass funnel; (15) retort; (16) cucurbit; (17) straw mat.

In the high schools, laboratory instruction developed quickly after its establishment in the colleges. College graduates who went into secondary school instruction brought with them a feeling for the importance of laboratory work and systematic instruction in the laboratory developed rapidly. The work was often extensive in character and well integrated into the rest of the study of science.[5]

In fact, as one examines the trends in laboratory instruction today, both in high school and college laboratories, one wonders if there has not been a decline both qualitywise and quantitywise. It is somewhat disconcerting today to see numerous laboratory manuals which merely call upon the student to supply missing words or to select the correct answer from a number of suggested choices. Many laboratory experiments merely involve a rediscovery of the obvious. There is a real question as to how much value is gained by having a student do an experiment when he already knows what the outcome is going to be. It would seem much

[2] Lockemann, G. and Oesper, R. E., "Friedrich Stromeyer and the History of Laboratory Instruction." *Journal of Chemical Education,* Vol. 30: 202; No. 4, April 1953.

[3] Van Klooster, H. S., "The Beginnings of Laboratory Instruction in Chemistry in the U.S.A.," *Chymia.* Vol. 2, 1949.

[4] Menschutkin, B. N. "A Russian Physical Chemist of the Eighteenth Century." *Journal of Chemical Education,* Vol. 4: No. 9, 1079; September 1927.

[5] Cary, C. P. *Manual of the Free High Schools of Wisconsin.* Madison, Wisconsin: Democrat Printing Co., Seventh Edn. 1914. Contains much information about science courses, objectives, subject matter, and apparatus.

more valuable to do a smaller number of experiments and have them designed in such a way that the student had to do some real planning in arriving at his results.

Quantitywise, too, there may be deterioration in the emphasis on laboratory work. A survey of students taking freshman chemistry at the University of Wisconsin between 1947-49 revealed some rather striking figures to bear this out.[6] Of 2532 students taking freshman chemistry, 21.5 per cent had taken no high school chemistry. Of the 1971 students who had taken high school chemistry, 22.6 per cent had had no laboratory experience in high school. Of the 1551 having done laboratory experiments, only 37 per cent had had opportunity to do individual experiments. Fifty-one per cent of the students worked in pairs, five per cent worked in larger groups, and the remainder said they had helped the teacher do experiments. While teamwork experiments may be necessary, under certain circumstances their value is to be questioned as a regular procedure. I am always reminded of the remark about teamwork made by my late colleague, Professor Francis Krauskopf, who taught freshman chemistry at Wisconsin for many years. Professor Krauskopf, who was of rural origin, said his father had a "willing team." One of the horses was willing to work and the other horse was willing to let him. So often teamwork experiments in the laboratory end up just that way.

So far I have limited myself to the development of chemistry laboratories but we are still interested in the development of laboratories in other sciences. It actually turns out that the first laboratories were probably not chemical at all. One of the earliest records of an institution having what may be termed laboratories, is found in connection with the Museum of Alexandria which flourished for three centuries before Christ and declined for several centuries thereafter. The Alexandrian Museum at its earliest and greatest period was much more than a library. There were botanical and zoological gardens, anatomical theaters, and observatories. It is not possible to learn if laboratory instruction of students took place there but there is no question that research was carried out. Subsequently there is a long lull during which there is no record of formal laboratories or laboratory instruction. There were observatories and there were philosophers who investigated problems of natural science during the Dark Ages but it is only in the seventeenth century that we began to again see an enthusiastic investigation of the problems of nature.

Physics has always lent itself to the study of its phenomena in the home, in the shop, or even outdoors. Galileo and Rumford carried out some of their experiments in armament factories. Boyle worked in his home, as did Cavendish, but gradually the laboratory began to have a definite place in educational institutions. The physics and biology laboratory developed in such institutions side by side with the chemical laboratory.

Laboratories in Government

In the past century we have seen a very widespread development of laboratories in government, in industry, and in noneducational institutions. Agricultural experiment stations, regional laboratories, bureaus of chemistry, and bureaus of standards have flourished not only in our own government but those of foreign nations as well. In industry the laboratory has developed rapidly, at first very largely for control purposes. Today we see an extensive trend toward industrial research, not only in the applied field but even to some extent in the field of pure science. As examples of institutional laboratories, one needs merely to mention the Pasteur, Curie, Mellon, Rockefeller, and Boyce Thompson Institutes.

Many of these laboratories have budgets running into hundreds of thousands of dollars per year. They are staffed with highly trained scientists and are equipped with expensive instruments which are the products of years of development. Some of these instruments are capable of performing in a few moments analytical jobs which would take a corps of chemists many years.

However, despite the brilliance of their personnel, the size of their budgets, and the ingenuity of their equipment, the success of today's great laboratories is still dependent upon the educational laboratory. Educators must not become overwhelmed by costly and intricate apparatus. The instructional laboratory can still function most effectively by remaining simple and exploring fundamentals. Sticks and pieces of string, kitchen chemicals, and backyard insects can still teach and inspire, often better than the most expensive instruments. The alert mind, guided by the enthusiastic and understanding teacher, is still needed in laboratory training.

[6] Martz, Evelyn L. *Studies on the Scientific and Mathematical Background of Students in Beginning College Chemistry Courses.* University of Wisconsin: B.S. thesis (unpublished), 1949. A mimeographed summary by Ihde and Martz is available upon request to the author.

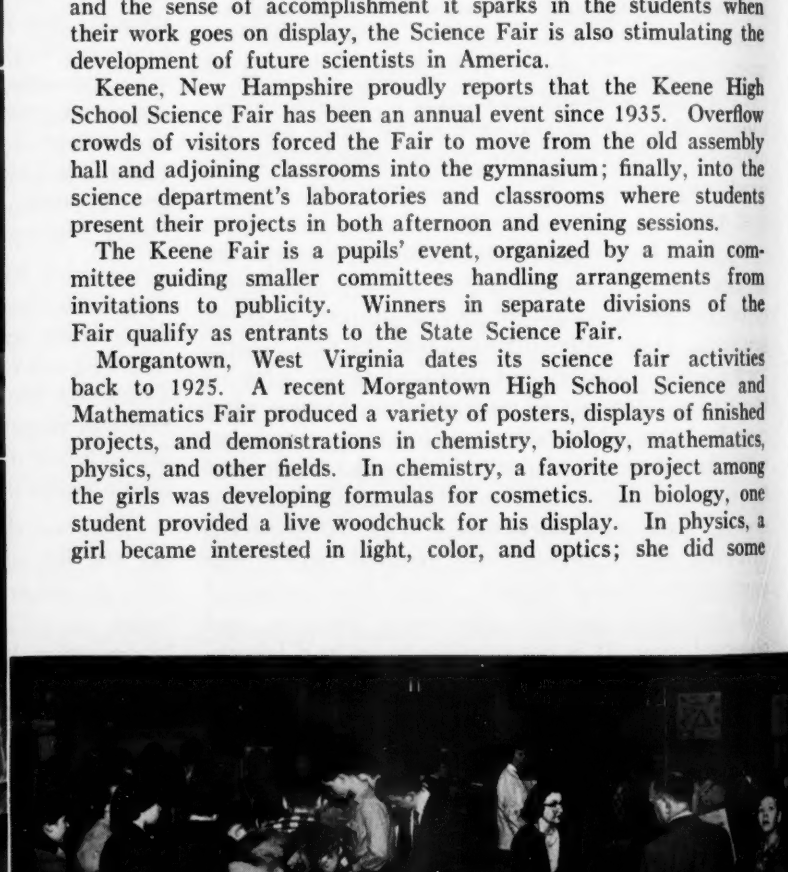
A Keyhole Look at

From East to West, from North to South, in sprawling cities and small farm communities, the Science Fair has become an important event in the school year program. Planned generally by students themselves with the help of teachers and sometimes with the aid of parents and industry, the Science Fair is now a popular community attraction. No longer a program confined to junior and senior high school grades, it is being introduced in elementary schools. And, in addition to the fun it gives the student participants, the challenge it presents to their skills and ingenuity, and the sense of accomplishment it sparks in the students when their work goes on display, the Science Fair is also stimulating the development of future scientists in America.

Keene, New Hampshire proudly reports that the Keene High School Science Fair has been an annual event since 1935. Overflow crowds of visitors forced the Fair to move from the old assembly hall and adjoining classrooms into the gymnasium; finally, into the science department's laboratories and classrooms where students present their projects in both afternoon and evening sessions.

The Keene Fair is a pupils' event, organized by a main committee guiding smaller committees handling arrangements from invitations to publicity. Winners in separate divisions of the Fair qualify as entrants to the State Science Fair.

Morgantown, West Virginia dates its science fair activities back to 1925. A recent Morgantown High School Science and Mathematics Fair produced a variety of posters, displays of finished projects, and demonstrations in chemistry, biology, mathematics, physics, and other fields. In chemistry, a favorite project among the girls was developing formulas for cosmetics. In biology, one student provided a live woodchuck for his display. In physics, a girl became interested in light, color, and optics; she did some



SCIENCE FAIRS

in Pekin, Illinois; Keene, New Hampshire; New Hyde Park, New York; Morgantown, West Virginia

This feature is a condensation of articles written by the following: Virgil C. Dollahon, Physics Instructor and Science Fair Chairman, Pekin, Illinois, Community High School; Arthur Houston, Head of the Science Department, Keene, New Hampshire, High School; Miss Flora Kahme, Science Department, Herricks Junior High School, New Hyde Park, New York; and Herbert McMillen, Chemistry Instructor, Morgantown, West Virginia, High School. The photographs were selected from those submitted by each of the authors.

research and presented her findings in a talk at the Junior Academy of Science.

The Morgantown Fair was not commercialized in any way. No admission was charged; no soft drinks, candy, or peanuts were sold.

Pekin, Illinois reports on its second annual Science Fair held last March. A cooperative effort of the Pekin Community High School and industry, it attracted more than 6000 parents, students, teachers, and school patrons. "Science in Action" was the theme of the Fair which presented 250 student projects and 31 industrial and technical booths. These filled the school cafeteria and lined the walls of the long adjoining corridor.

Herricks Junior High School, in New Hyde Park, New York, held its first Science Fair last November. A three-day exhibit, it was housed in the school gymnasium where tables were arranged cafeteria style for the displays. Parents cooperated, transporting the working youngsters and helping set up and take down projects. Virtually every boy and girl in the 22 science classes at Herricks Junior High School submitted a project and each received a wallet-sized card of congratulations and commendation.

From Herricks comes the report of the statement spoken again and again by Fair visitors: "Excuse me a minute, there's something I want to look at just once more." In similar phrases, it is being said wherever Science Fairs are held throughout the country.

Counterclockwise, beginning at the top of the opposite page, the photographs show: 1) A group at the Herricks Junior High School Science Fair; the smiling man in horn-rimmed glasses, right center, is Henry Jacobs, head of the school's Science Department. 2) Classmates watch a Herricks Junior High School student demonstrate his model. These two photographs by Albert Vieira. 3) Ray Barnes, a chemistry student at the Pekin Community High School, shows his blast furnace model. 4) Michael Bearden, a Pekin physics student, demonstrates his Tesla coil model to Robert Culshaw, of the Caterpillar Tractor Company, Peoria, Illinois, and his teacher, Virgil C. Dollahon. Photograph courtesy of Caterpillar Tractor Co. 5) A scene at the afternoon session of the Keene High School Science Fair, when young visitors were in the majority. Photograph by Burns Photography Inc. 6) (Bottom of this page) A young student at the Morgantown High School Science and Mathematics Fair demonstrates his reflux condenser used to hydrolyze starch to sugar. 7) Two Morgantown students show their pyramid, for which they moulded more than 900 bricks. These two photographs by The Morgantown Post. 8) Madi Magner displays her project for which she won a 3rd Award in the Keene High School Science Fair. 9) Carolyn Adams with her antibiotics project which won her a 2nd Award in the Keene High School Science Fair and a 2nd Award in the New Hampshire State Science Fair. These two photographs by Charles D. Reynolds.

HOW TO EVALUATE A FIELD TRIP

By RICHARD B. FISCHER *

Assistant Professor of Science Education, Cornell University, Ithaca, New York

THE SCIENCE TEACHER TRAINING PROGRAM at Cornell University includes a course called Field Natural History. Formerly it was taught by Professors E. Laurence Palmer and Eva L. Gordon—names I am sure are familiar to you—and it is my pleasant assignment to carry on the fine traditions they established. The course has two goals: (1) to acquaint prospective teachers with the natural history materials they are likely to find in the vicinity of their schools, and (2) to teach ways in which the materials can be used to motivate, clarify, and enrich their teaching.

The course is organized on the basis of weekly, 3½-hour field trips. Most trips are taken on or close to the campus where conditions resemble those the cadet teachers will find around the schools they go to. There is emphasis throughout on using materials near the school, for teacher and students can get to them within the ordinary class period, and both can conveniently re-examine the items at a subsequent time.

As a rule, biweekly quizzes are taken outdoors, during a regular field trip, where students see different examples of the items they learned about on previous occasions. They are asked to name objects, answer questions about them, and indicate how they might be used in teaching situations.

We begin with identification, but that is only a beginning. A teacher must be able to recognize the elderberry plant if the objective is to obtain pith for pith balls from it, or the giant water bug which would kill all the small fish in the classroom aquarium, or the wild parsnip that might leave a bad case of dermatitis as a reminder of a good field trip.

In order to see teaching possibilities, one must have an acquaintance with the natural history materials around him. The teacher needs to be able to name things, for then he can turn to reference books and other sources for the information on which he will build lessons and shape activities.

Now, since natural history is so much more than mere names, we do not stop with identification. For instance, some of the plants we study provide excellent demonstration material for basic concepts of botany. Others are hosts for insects or fungi that cause serious crop damage. Some, like black cherry, have high commercial value. In general, then, I try to give the class a usable knowledge of the many inter-relationships that exist among living things. A person who uses such knowledge ought to make his teaching more meaningful, more inspirational, and, I daresay, more pleasant for himself.

Part way through the course we spend an afternoon in a small park adjacent to the city high school. There each student teacher "teaches" a 20-minute outdoor lesson on some aspect of natural history, using whatever materials he can find in the park. A critical discussion follows each lesson. This is another means of evaluating what the students have learned and how they are able to use their knowledge.

By describing a specific field trip, I can illustrate other methods of evaluation. Just before Christmas we study the coniferous trees. This unit I save for Christmas time since that is an occasion when everyone is more aware of conifers. Here is our approach to the material.

We go to an area on campus planted with many conifers and, in the outdoor setting, pool what the students already know about the biology, ecology, and uses for the trees. The open discussion lasts about half an hour. As a result we bring together much of the information I feel the students should have; the remainder I fill in during the field trip. It is, by the way, always interesting to note how much a class, as a group, knows about conifers even though no single student might be particularly well informed. This sharing of knowledge on field trips is one of the things that contributes to *esprit*, and to rapport with the professor.

Some of the major points about conifers that might evolve from the preliminary discussion are these:

a) A workable definition of "conifer" as it applies locally
b) The beauty of songs, poetry, and pictures associated with them

* Adapted for publication from a panel presentation at the joint meetings of the science teaching societies affiliated with the American Association for the Advancement of Science, Atlanta, Georgia, December 29, 1955.

An aim of field work is to develop powers of critical observation and description. Here students in Field Natural History examine structural details of a Japanese yew.

c) Their use at Christmas, and how the tradition arose

d) The extensive use of conifers in ornamental plantings

e) Their ecological relationships with other plants, with wildlife, and with man

f) The large monetary value they represent in terms of lumber, pulp, etc.

This is a formidable list when all the fascinating little details are added, but those are the things a teacher can draw on to extend his students' feelings and appreciation for conifers beyond the Christmas season.

With interest thus aroused, the class is ready to examine some conifers. First we look at a spruce, for example, with respect to its needles, twigs, branches, cones, color, shape, and size. After noting the distinctive characters, I identify the specimen to genus (if necessary) and to species. This procedure is repeated with other genera—firs, pines, cedars, junipers, yews, etc. Early in the trip, therefore, students learn to recognize the different groups of conifers. For each specimen we add information that supplements our preliminary discussion. This includes data on preferred habitat, how to estimate the tree's age or that of a branch, simple details of reproduction, how long the cones take to mature, and other pertinent facts concerning each specimen.

As the trip progresses, we see and study more examples of the major groups. Where permissible, the collector for the day removes a small sample from each tree. He labels the specimens with gummed paper and carries them in a vasculum. At the close of the trip, the collector places the specimens in water for those who wish to study them further.

As an immediate follow-through to studying the trees in the field, we return to the laboratory and work out a key to the local conifers. With the information fresh in their minds and the specimens before them, the students find this is a simple yet stimulating assignment. After the class has designed a key, I pass out a mimeographed version which experience has shown usually matches theirs quite closely.

One of the aims of field work is to improve the ability to observe and describe structural details. To evaluate progress with respect to conifers, I

(Please continue on page 369.)

The 1956 Science Achievement Awards Program in Region VII

By STANLEY B. BROWN

School of Education, University of California, Berkeley

ONE of the less publicized facts about the fifth annual program of Science Achievement Awards for students deals with information about the entrants; i.e., their State representations, a breakdown of entries by grade levels, the subject matter of projects, the boy-girl ratio, and similar data. This information has been compiled for Region VII, in which science students from Colorado, Kansas, Missouri, New Mexico, Oklahoma, and Texas took part in the awards program.

The judging group for Region VII has also reported the procedures followed in evaluating each entry and selecting the winners. It is believed this information will help science teachers guide their students who participate in the 1957 and subsequent Science Achievement Awards.

Entrant Data

Table I contains a breakdown by State and grade level of the 331 entrants in the 1956 program.

Table I

States	Grade Levels within States						Totals
	7	8	9	10	11	12	
Colorado	1	3	13	29	9	5	60
Kansas	0	2	5	0	0	0	7
Missouri	10	6	15	4	17	6	58
New Mexico	0	0	10	0	0	2	12
Oklahoma	19	12	31	10	15	25	112
Texas	1	8	19	9	27	18	82
Grade Level Totals	31	31	93	52	68	56	331

The following 11 science-mathematics categories were selected as the most workable guides to the entrants' specific fields of interest.

Anthropology
Astronomy
Botany
Chemistry
Geology
Mathematics
Medicine and Human Physiology
Physics
Psychology
Science Fiction, Pseudo-science
Zoology

Table II illustrates by general subject categories and grade levels an indication of interest in science and mathematics projects by Region VII students.

Table II

Subject Category	Grade Levels within Subject Categories						Totals
	7	8	9	10	11	12	
Anthropology	1	0	1	0	0	0	2
Astronomy	2	1	4	0	2	0	9
Botany	2	2	7	7	5	1	24
Chemistry	1	4	13	3	10	11	50
Geology	15	4	12	8	5	4	48
Mathematics	0	0	1	1	9	1	12
Medicine and Human Physiology	2	5	11	7	10	9	44
Physics	4	10	31	8	19	25	97
Psychology	0	0	4	2	4	3	13
Science Fiction, Pseudo-science	0	0	1	0	0	2	3
Zoology	4	5	8	8	4	0	29
Grade Level Totals	31	31	93	52	68	56	331

Of significance is the fact that among the entrants apparent interest in the physical sciences is twice that of the biological sciences (219:112). An assumption may be made that even though a larger number of science students are enrolled in high school biology and/or biological aspects of 7-9th grade general science, their interest in the physical sciences is far greater.

With respect to the boy-girl ratio of the entrants, Table III gives this information in both overall and subject-category breakdowns.

The indicated interest patterns are somewhat unique in that the boys selected "Medicine and Human Physiology" at a ratio of seven entries to 37 for the girls. Although the boy-girl contribution on the overview is 183:148, the medicine and physiology figures support a well-established opinion held by science teachers, namely, that it is a myth that interest and participation in the sciences lies in the male domain.

Table III

Subject Categories	Number within Subject Categories		Totals
	Boys	Girls	
Anthropology	0	2	2
Astronomy	7	2	9
Botany	11	13	24
Chemistry	23	27	50
Geology	25	23	48
Mathematics	12	0	12
Medicine & Human Physiology	7	37	44
Physics	76	21	97
Psychology	5	8	13
Science Fiction & Pseudo-science	2	1	3
Zoology	15	14	29
Totals	183	148	331

Judging Procedures

In Region VII, the entries were mailed to the regional chairman, who had them carefully checked according to the brief contest regulations; i.e., did the code number and entry title tally, was the entry complete, was it received within the deadline date, etc. The chairman, having obtained a competent judging team, then set up the time schedule for an objective and thorough assessment of each entry. A total of 12 judges plus the chairman constituted the judging group. The members represented fields of specialization in the respective broad science and mathematics areas as well as grade levels 7-12. At the university level, certain judges represented the academic science and mathematic areas as well as supervisor and curriculum specialist groups.

Divided into three groups of four, the judges met as a total group (13 with the chairman) in a large demonstration room. After an orientation session which included clarification of procedures, the 7th and 8th grade level group proceeded to a corner of the room where the entries of these levels were laid out on large tables for evaluation. The 9th and 10th, and 11th and 12th grade level groups proceeded to their respective areas, and the regional chairman devoted his time as a intermediator and interpreter. Where necessary, he took part in the decision procedure. After every entry had been examined by each member of the select judging team, the Honorable Mention entrants were determined. From these, after vigorous and serious deliberations, the Winners were named.

ADVENTURES IN SCIENCE

By PAUL F. POEHLER, JR.

Coordinator of Elementary Science, Lexington, Massachusetts, Public Schools

THE HISTORIC MASSACHUSETTS CITY, Lexington, is adding its bit to modern science history through a new program which utilizes community resources for the enrichment of science interest. The Junior High School is sponsoring a series of monthly evening programs called "Adventures in Science," which are designed for parents and other adults as well as students.

Located near Harvard University, the Massachusetts Institute of Technology, and M.I.T.'s famed Lincoln Laboratory, Lexington is also adjacent to Air Force research installations and to electronics industries which recently have concentrated in eastern Massachusetts. Thus, a large number of the community's residents are research scientists, college professors, and electronics and engineering executives. They are people who are not only interested in the schools but are also anxious to serve them in every way possible.

Quick to realize that the unusual abilities of this group might well be channeled toward the enrichment of the school program, the school's science staff took the initiative and enlisted the aid of the group in arranging the evening programs. Now, once each month an interesting science program is brought to the Junior High School. These programs have been as enthusiastically received by the adults as by the students.

To date, "Adventures in Science" has included presentations by Raytheon, Monsanto Chemical Company, General Radio, and General Electric. Of special interest was a live demonstration of a Van de Graaff generator by research scientists rebuilding the original generator at M.I.T.

It is the general community opinion that the programs have been markedly successful in stimulating a high regard and esteem for science. "Adventures in Science" has created a new bond of interest between students and adults. And the program, from the viewpoint of the school system's relationship with the community at large, has been a highly successful accomplishment in public relations.

DISPLAY AREAS AND THE GROUP TECHNIQUE

By THEODORE W. MUNCH

College of Education, The University of Texas, Austin

TIME is the teacher's villain when plans are considered for displays of pictures and objects in the classroom. Few teachers would question that visual aids help immeasurably in making science subject matter more meaningful to students. In a teacher's busy day, however, there is little time for the frequent assembling of displays. The solution to the time problem can well be use of the group technique.

The teacher can have the entire class take part in the construction of display areas by selecting small committees to present their work to the class throughout the year. When such a plan is incorporated into the curriculum, the successful completion of the display area calls for careful teacher planning and supervision.

The following suggestions have been gleaned from experiments conducted with two classes of biology and one class of personal hygiene in the 13th grade of Fullerton Junior College, Fullerton, California. Approximately 120 students were involved in the experiment, and many of the ideas which follow were drawn from answers to a questionnaire filled out by each student following the completion of his display area. The technique described can be used for children of almost any age.

The phrase "display area" is preferable to "bulletin board," since bulletin boards are usually in two dimensions, while display areas have the third dimension of depth. Display areas may consist not only of the usual bulletin board background, but also of objects and/or specimens related to the bulletin board material and arranged in front of or around it.

Grouping of Students in Committees

Planning for the display areas should begin early in the semester, preferably following the first week or two after the students have had a chance to grasp, in a general way, the nature of the year's work.

The instructor should make an inventory of the interests and talents of class members by asking them to list problems or questions which are of particular interest or concern to them. The teacher can suggest problems and areas of interest which former students found appealing. The students should have several days to consider their choices, during which time they can discuss their interests among themselves and with the teacher. Each student should make three choices of subject matter areas, listing his choices in the order of their importance to him.

The teacher now chooses the committees, grouping the students on the basis of first choices until the optimum size of the committee has been reached. The committee number which the students termed "just right" was four. With a greater number, there is difficulty getting the members together at one time for planning sessions. Also, the less "vocal" students tend to become members of an "out group," while most of the ideas and information are contributed by the more aggressive students. On the other hand, committees of fewer than four tend to be restricted in ideas.

This and the illustration on the opposite page are photographs by Dr. Munch of displays constructed in his classes.

Teacher Planning Prior to Student Committee Meetings

The following general suggestions by the teacher to the class before student committee work begins have been found helpful for a good beginning.

a. Select a coordinator or director for your committee. The coordinator is not to do all the work, nor is he to be held responsible for the success or failure of the display area. His job is to help see that there is no duplication of research, material, or labor.

b. When your committee first meets, decide how much of the topic chosen will make an adequate presentation on the display area. Remember you are limited in space; the ideas presented will have to be concise.

c. Once you have decided on a topic for display, read as much as possible about it. You may want to confer with people in the community in a profession or in industry. As you gather information, make notes for future meetings on small cards or in your notebook.

d. When your committee next meets, discuss or read what you have found in your research and come to an agreement on the important points for the display.

e. In succeeding meetings, each committee member should make a sketch showing how he would like to see the important points of the display presented.

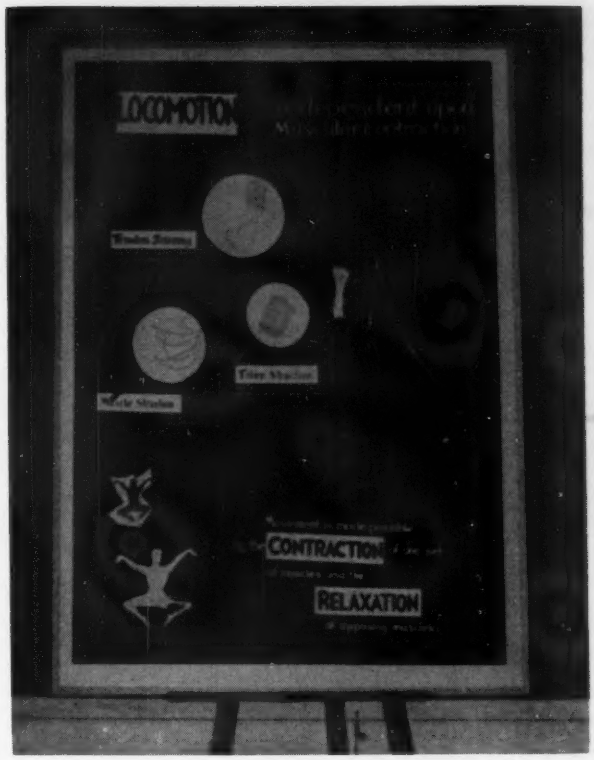
f. When the committee is in agreement on the design of the display, proceed to the problem of securing materials.

g. When all your materials are assembled, the final step is to erect your display and present your material to the class.

h. Evaluation of the display area should be based on the following points. (These may be arrived at by class discussion, but the teacher should be responsible for the weight given to each area of the evaluation.)
   (1) Importance of the scientific ideas presented
   (2) Accuracy of the material
   (3) Originality of the display area
   (4) Form or "mechanics" of the display

Teacher-Pupil Planning Prior to the Presentation of the Display

To insure that the students get well organized, the teacher should attend the first one or two committee planning sessions. A common pitfall to avoid is the choice of a topic too broad for display presentation. The teacher should also make sure



that all members of the committee have an approximately equal role in the planning and execution of the project. During these early sessions, the instructor can help the students gain insight into the "give and take" of successful group work. He should point out specifically that groups such as these form the "backbone" of much of our democratic life, and that learning to work with others is a valuable skill in all areas of living. The instructor should feel free to suggest general references for information. If the committee is solving its problems satisfactorily, no attempt should be made to interfere, even if the project is not being planned as the teacher had conceived it.

Follow-up by the Instructor

Periodic checks should be made by the instructor; i.e., asking individuals what information they have discovered, what ideas they have for presentation, and if everyone is contributing equally.

When display areas are made a part of the curriculum, class time should be allowed for some of the planning and work sessions, possibly during supervised study periods. The students should know, however, that some outside time and effort (call it homework) will probably be necessary.

The students may need considerable assistance in procuring simple supplies such as tacks, pins,

and tools (stapler, ruler, scissors). A materials center, consisting of a cabinet in which supplies are stored and a table where the students can work, is essential to the easy preparation of display areas. When each display is dismantled, students should return to the materials center all reusable supplies.

Presentation of the Display Area

The presentation of the display should be timed to coincide as much as possible with the planned lesson. This procedure necessitates a rather flexible schedule. Each committee should be notified several days in advance of the day of presentation.

Class time should be set aside during which the committee (or selected members) presents the display to the class and answers questions concerning the science principles behind the display. The teacher should be ready to amplify as much as is necessary and to preside over a friendly critique by other members of the class. The importance of good teacher direction at this point in the presentation cannot be overemphasized. Display areas can and should represent important highlights of a science topic. The display may be used as a skeleton about which to drape many interesting or vital facts concerning class work developed in the immediate past or to be studied in the immediate future. The instructor should integrate with the display as many points and interesting details as possible in order to fully justify the use of class time for this type of presentation. The time spent in hearing how other students react to the display is especially valuable for those still planning displays.

Student Reactions to the Use of Display Areas as a Group Technique

a. The students revealed that many sources were used to obtain facts for the display areas. The textbook and other committee members were the two most important sources. Magazines and pamphlets from the library were also found to be valuable sources. Many students consulted members of civilian agencies outside the school.

b. About half the students reported that not all committee members worked equally in preparing the display. The reasons given were that some members had to work and could not be present at all planning sessions (this could be avoided by allotting sufficient class time for this work) and some of the committees were too large.

c. A majority of the students agreed they would prefer not to work by themselves. Some of the reasons given were: they needed to learn to work together; one person rarely had a sufficient number of good ideas; and it would have been impossible to gather sufficient data alone. Some students would have preferred working alone because: they did not agree with the ideas expressed in the finished display; they would not have had to worry about others shirking their responsibilities; some committees were too large; meeting times were too hard to arrange; and some considered it unfair to evaluate a group on a project to which all did not contribute equally.

d. Only a few students relied on present knowledge from which to draw ideas. The majority agreed that they learned new facts during the preparation of the display, mainly because they had to seek out non-text sources.

e. A majority of the students felt that this type of group project should be used again in other classes. Among their reasons were that this technique: aids in better understanding of the problem involved; enables certain members of the class to express themselves more easily; is superior to the lecture method in presenting facts; and is interesting and fun.

f. The individual committee members spent as much as eight hours and as little as one-half hour in pre-planning discussions. The average was about two hours. Individual research for facts and ideas of presentation demanded as little as one-half hour and as much as 16 hours. Erecting the display consumed as much as 11 hours per individual but the average was between one and three.

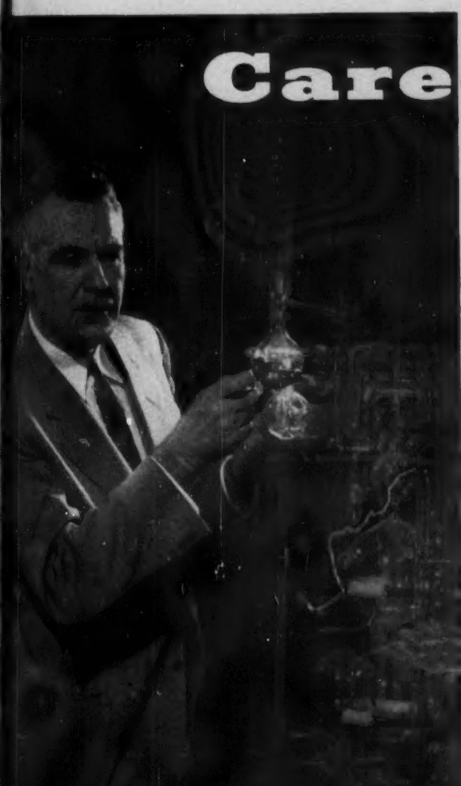
g. The cost of the display ranged from nothing to slightly above $1 per individual. The average cost per member was 50¢.

The use of display areas as a group technique can be made successful only if certain things are true. The teacher must be philosophically disposed to believe that education, even in the areas of science, consists of learning more than just facts, principles, and concepts, and that the display area technique is one way of helping students achieve successful inter-personal relationships. The teacher must be able and willing to spend the time necessary to see that the committees get organized and keep progressing. Finally, he must be ready to accept the fact that some part of the course of study must be set aside if ample time is to be allowed for the development of adequate display areas.

SCIENCE PROJECTS

as Stepping Stones to

Careers in Science



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Columbia High School
Richland, Washington

BOHLEN, (MISS) ANNE
Franklin High School
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CONNORS, (MISS) MARION R.
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CUMMINS, ERNIE LEE
North Salem High School
Salem, Oregon

DOMM, ELGIN C.
Del Norte County High School
Crescent City, California

DRAKE, DONALD M.
Thomas Downey High School
Modesto, California

EVERETT, A. W.
Sanger Union High School
Sanger, California

FIESS, PAUL E.
U. S. Grant High School
Portland, Oregon

GREISEL, MRS. IRMA JOY
Gresham Union High School
Gresham, Oregon

HERBAGE, WARREN R.
Highline High School
Seattle, Washington

HESS, ADRIEN (Observer)
Montana State College
Bozeman, Montana

JENSEN, EDWIN
Elko County High School
Elko, Nevada

JORDAN, LEON E.
Phoenix Camelback High School
Phoenix, Arizona

KARLIN, SOL ALLEN
Robt. Fulton Junior High School
Van Nuys, California

LAHTINEN, (MISS) LYNNE
Yuma Union High School
Yuma, Arizona

LOUDERBACK, H. M.
Lewis and Clark High School
Spokane, Washington

MAEHLING, LEON H.
Yuma Union High School
Yuma, Arizona

MILLER, GEORGE
Sedro-Woolley High School
Sedro-Woolley, Washington

MORT, MRS. FAY
North Salem High School
Salem, Oregon

NELSON, MERLIN W.
Coeur d'Alene High School
Coeur d'Alene, Idaho

PENGELLY, RUSSELL J.
Fremont Junior High School
Klamath Falls, Oregon

PETERSON, GLENN H.
Grace High School
Grace, Idaho

PUTNAM, JOHN A.
E. S. Meany Junior High School
Seattle, Washington

RASMUSSEN, STEVE R.
Las Vegas High School
Las Vegas, Nevada

RENEAU, ARTHUR CHARLES, JR.
Selma Union High School
Selma, California

SCHROEDER, CHARLES HARRY
Kelso Junior High School
Kelso, Washington

SCOTT, MRS. SARAH
Sequim High School
Sequim, Washington

STUDER, LOREN E.
Pendleton Senior High School
Pendleton, Oregon

TITUS, DARREL E.
Prosser Junior High School
Prosser, Washington

WARD, MRS. KATHRYN D.
Beaverton Union High School
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La Cumbre Junior High School
Santa Barbara, California

FOURTH ROW—Williamson, Studer, Domm, Rasmussen, Reneau, Bench, Nelson
THIRD ROW—Peterson, Wolfe, Drake, Jensen, Herbage, Everett, Cummins, Carleton
SECOND ROW—Titus, Pengelly, Louderback, Karlin, Miller, Maehling, Jordan, Schroeder, Putnam, Fiess
FRONT ROW—Berdan, Greisel, Lahtinen, Ward, Mort, Bohlen, Connors, Scott

PHOTO BY OREGON STATE COLLEGE

SCIENCE PROJECTS as Stepping Stones to Careers in Science

The Conference

The picture on the opposite page was taken at the Third Annual West Coast Summer Conference for High School Science Teachers, Oregon State College, Corvallis, June 17-30, 1956. The 31 participating science teachers came from the states of Washington, Oregon, California, Idaho, Utah, Nevada, and Arizona. Their selection was based on evidence of interest and experience in stimulating students to do and report individual project work in science. Applications were honored from teachers, supervisors, coordinators, and directors of science in grades seven through twelve.

The conference was conducted by the Future Scientists of America Foundation of the National Science Teachers Association in cooperation with Oregon State College and the Crown Zellerbach Foundation. Each participant received a $200 Fellowship from the Crown Zellerbach Foundation. The conference provided three hours of graduate credit from Oregon State College for those who wanted it, with the tuition paid by FSAF.

These experienced teachers gathered data while visiting industrial establishments and research laboratories and interviewing biologists, chemists, physicists, geologists, engineers, and other scientists. The visits and interviews enabled the Fellows to learn how successful scientists identify projects, design lines of attack, solve their problems, and report the results. From this, the work and study groups extracted implications appropriate for science in grades seven through twelve. These implications were then translated into guiding principles, recommendations for teachers, and ideas for improved projects. The recommendations based on the guiding principles are found throughout this report; they are related to the general text but are guideposts on their own.

The participants, guest lecturers, research scientists, and coordinators of the conference sincerely hope science teachers can make effective use of this report in developing realistic and meaningful projects as "Stepping Stones to Careers in Science."

ON THE COVER

THE STUDENT SCIENTIST: Lawrence Page is shown demonstrating his "rockets and jets" model which he developed as a student project in his junior year at Keene (New Hampshire) High School. For it, he was named 1st Award Winner in the Keene High School Science Fair (Physics) and 2nd Award Winner in the New Hampshire State Science Fair.

PHOTO BY CHARLES D. REYNOLDS

THE CAREER SCIENTIST: Dr. John R. Pellam, professor of physics at the California Institute of Technology and noted investigator in the field of low-temperature physics, is shown with some of the specialized equipment used in his studies of liquid helium which he has carried close to absolute zero. This is nearly 460 degrees below zero on the Fahrenheit scale and theoretically the lowest temperature possible.

PHOTO BY RICHARD HARTT

The Working Assumptions

If the design of student projects is improved to the point where the projects provide realistic, meaningful experiences for students, larger numbers of capable students will be stimulated to follow science-related careers.

If teachers can acquire a knowledge of how successful scientists identify projects, design lines of attack, solve their problems, and report the results, and then implement these processes whereever possible, student projects will become more realistic and meaningful in revealing what kinds of work scientists do and how they do it.

What Did They Say?

The West Coast Conference was "spiced" with several invited lecturers who were specially experienced in the area of student science projects. Those serving in the capacity of guest lecturers,

and in other ways, and the topics they discussed were:

1. Dr. Ralph Tyler, Director of the Center for Advanced Study in the Behavioral Sciences, Stanford, California; "Evaluating the Outcomes of Student Project Work"
2. Dr. Oreon Keeslar, Coordinator of Secondary Curriculum, Santa Clara County Schools, San Jose, California; "Problem Solving in Teaching Science"
3. Dr. Arthur Scott, Department of Chemistry, Reed College, Portland, Oregon; "How the Reed College Faculty Upgrades College Science Students"
4. Dr. William Crooks, Professor of Psychology, Oregon State College, Corvallis; "Psychology of the Problem-Solving Method"
5. Dr. Donald Stotler, Supervisor of Science, Public Schools, Portland, Oregon; "Getting Projects Started"
6. Dr. John S. Richardson, then *President-elect of NSTA,* Professor of Education, The Ohio State University, Columbus; "Requirements of a Science Project Program"

Here are some of their thoughts on the many facets of project teaching considered during the conference.

Educators are concerned today with the loss of interest in science among students somewhere between grades nine and twelve. Therefore, something must be done to nurture scientific curiosity in youth. Realistic, interest-centered projects may be the answer to this problem. How to develop or encourage such projects is a challenge.

RECOMMENDATION

If the teacher can spend time "talking science" to the student as opposed to "lecturing science," this more personal approach will help the student become aware of new problems which exist about him.

The best projects grow from problems the student finds for himself, just as easily as they grow from problems faced by the research scientist.

The teacher's role is also to encourage the student not to give up quickly and to remember that pleasure can be derived from solving problems.

Projects are a means for discovering latent science ability. They meet the needs of the individual. Like shoes, they should fit the individual; they must lend support without becoming restrictive. They must be attractive in his mind's eye lest he lose interest and leave them in the closet to gather dust. They can show the path the wearer is taking; is he on stepping stones or in quicksand? Like baby shoes, they serve their purpose. At the proper time, they become exhibit pieces when a more substantial pair fits the maturity of the wearer. Projects, too, must be of the right size to fit the student.

RECOMMENDATION

Every science teacher should have a research project of his own to interest students and show problem-solving techniques by precept and example. This will also lift the science teaching profession in the eyes of scientists and the community.

If the personal origin of projects is to be maintained, they can only be "suggested," not "ordered," by the teacher. Latent science ability can be squelched by this method of "assigning" projects. There can be projects for all students, too, if they fit. Why should just the "brains" or the "top few" be permitted to do projects?

Projects for the sole purpose of having something to enter in a "science fair" or for "raising grades" is not a justifiable practice. Projects must have the personal interest origin if they are to be realistic and meaningful.

Sometimes, when projects become homework, they serve to bring a family closer together. Increased admiration for Dad and a better understanding of his occupation may result.

The effective teacher develops a tolerance for individual varieties of approach in project work. There are scientific methods, to be sure, which should be used, but is it not true that many successful scientists go beyond "traditional" patterns of investigation to solve their problems?

As the potential future scientist reaches his last year in high school, he should have some type of experience in actual laboratories in industry if there are opportunities for it locally. In this way the student becomes more aware of what he can achieve in science.

The use of the resource speaker is one of the most effective means at the teacher's disposal for stimulating student science interest. With the teacher's advice, the selection of such speakers for assembly programs and science club meetings can make science a fascinating subject. If a few stimulating resource speakers on science with interesting

and practical demonstrations visit a school, the number of projects will likely increase and with this will come greater interest in science classwork. Men and women from laboratories invited into a classroom can demonstrate ways they have solved their problems. They want to do it and the time required for it is justifiable in terms of resulting interest in science fields.

Why Do Projects?

The conference Fellows gave much attention to this question. Here are some of the best answers that came out of the conference.

Student projects can

- —stimulate and nurture scientific curiosity
- —develop self-satisfaction and scientific creativity
- —help the teacher meet individual differences
- —reveal latent abilities
- —add meaning to scientific principles learned in the classroom
- —involve problem-solving techniques (scientific methods and attitudes)
- —give exercise in critical and independent thinking
- —enable teachers to evaluate pupil behavior

Which Students Can Do Projects?

While teachers should make an effort to attract superior students to science projects, each student

- —should have the opportunity to do projects
- —should be free to choose according to his ability
- —should receive special encouragement if he is interested in a science career

When Should Projects Be Done?

Science projects originate when and where problems develop. Projects result from

- —a student's desire to solve a problem
- —the project method of teaching
- —a student's desire to enter a project in a contest or a fair

The conference Fellows recognized that many students—bus students, for example—will be denied the opportunity to do projects unless class time is used for this kind of activity. It is strongly recommended, therefore, that this be done even at the expense of "covering ground" in the textbook.

RECOMMENDATION

Students and teachers should make periodic trips to industry and research laboratories to visit with scientists, see actual projects underway, and get ideas for new and practical projects of their own.

Where Should Projects Be Done?

Places where student science projects have been done with good success include

- —the home
- —industrial laboratories
- —city science centers, such as museums
- —school laboratories before and after school
- —school basements and gymnasium storage rooms
- —summer vacation camps
- —local college laboratories

If a personal file on projects is maintained, part of it could be used for evaluation. A file of teacher observations, the student's write-up, project outlines, or project designs will help the teacher grade the student on his work when it is completed. An ancedotal record of each project can be used as a guide in future planning for project teaching.

RECOMMENDATION

Science teachers should be diplomatically aggressive in enlisting advisory consultants from industrial laboratories to assist the gifted science student in problem-solving experiences through projects.

Motivation and Limitations

The student is motivated to do a project through a variety of experiences ranging from his interests and hobbies to the desire for a better grade. Projects grow out of deep interest in studies, the mutual interests of teacher and student, and the stimulus of competitive science programs.

The limitations of time, space, materials, and finances cannot be overlooked. To overcome them, the project must be modified in such a way that it

fits the situation and still solves the problem at hand. This is where the skilled teacher is needed. In the modifying of projects, the important and well-known safety rules of the laboratory must be kept in mind.

Development of the Project

As general guides in the development of projects, the conference Fellows offer the following suggestions:

Preliminary Investigation
- —outline the project
- —state problem
- —study references available
- —survey materials needed
- —secure teacher approval

Procedure
- —collect materials
- —select bibliography and keep notes on reading
- —design and set up experiment
- —keep accurate records
- —interpret records by use of charts, diagrams, and models
- —study limitations of data
- —consider degree of accuracy of equipment
- —present periodic progress reports
- —evaluate project by means of student-teacher conference
- —present final report, preserving records

Evaluation

Though mentioned briefly in another part of this report, the group presents this summary on the reasons for, or uses of, evaluation of the science projects.

Evaluation
- —is helpful for teachers to learn how near they approach their goals
- —will help students in self-appraisal
- —provides a partial basis for marks or grades
- —is used as a means of selection for our future scientists
- —is used in the distribution of honors and awards
- —reveals effectiveness of techniques or activities as shown by pupils' behavior

The following recommendations on evaluation were prepared for the conference and this report by Dr. Ralph Tyler.

"In evaluating a project the teacher needs to keep clearly in mind: (a) the objectives on which he is seeking evidence; (b) the kinds of evidence which are relevant to each objective; (c) the ways in which the evidence can be summarized or graded; (d) the extent to which the individual student shows progress or development. The recommended purposes for projects suggest the objectives. The teacher will be looking for evidence of: (1) the student's scientific curiosity; (2) his interest in science; (3) his originality and creativity in planning and carrying on the project and in solving problems; (4) his growing understanding of his own latent abilities; (5) his understanding of science principles; and (6) his ability to do critical and independent thinking.

"Evidence relating to each of these objectives will often be obtained from observations of the student's work on the project, from conversations with the student about what he is doing and why, from the project outline and design, and from the student's write-up. In some cases, the evidence can be summarized by a rating sheet; in some cases, a verbal summary may be most appropriate, while in other cases it may be possible only to indicate the presence or absence of the desired objective."

RECOMMENDATION

Science teachers can be instrumental in increasing the number of traveling science demonstrations by testifying as to their effectiveness and requesting that such lectures be presented in their schools. This can sometimes be accomplished by the science teacher's consenting to be placed on the school assembly committee as an advisor or consultant.

RECOMMENDATION

Students should be encouraged to start projects early if they are to be submitted in any recognition program. Seasonal projects must be planned well in advance if they are to be a part of the classwork.

In using the project evaluation as one of the bases for assigning a grade, comparisons among students will be made. Evaluation is also a means of appraising the individual's progress. It can determine whether a major purpose of project work is being carried out; that is, is the project encouraging the student to engage in activities within his ability range and yet challenging him to go beyond

his present achievements. To do this, comparisons should be made between earlier and later performance of the individual student to identify the extent of his development.

Reporting of Projects

Reports vary as do the projects. While an oral report or demonstration of the project activity can be rewarding to the student, the writing of reports is necessary training for the dissemination of scientific knowledge later in life.

> **RECOMMENDATION**
>
> The science teacher will find it helpful to maintain a personal file on projects. Such a file should include articles which stimulate project work such as brief descriptions of projects, awards, science fairs, achievement programs, junior academies of science, and science congresses.

Reports made to groups of students help the reporter to gain poise and self-confidence. Most summaries will interest others in science and bring about adult support of projects. The best projects may be reported in the school and city papers. A written report may be designed in the following form.

Title

I Summary
- A. Topic or problem investigated
- B. The purpose of, or reason for, the investigation
- C. Important results or information gained from the investigation
- D. Suggested action based on the results of the project

II Discussion
- A. Circumstances leading up to the project
- B. Acknowledgment of help received from other people
- C. Methods used in making the investigation
- D. Conclusions and the reasoning upon which these conclusions were reached

III Appended Materials
- A. Drawings, photographs, graphs, tables, maps, calculations, and other evidence supporting the project report
- B. Other material dealing with the project not included under another listing

Helps

The following references may be of some help in counseling students who wish to do projects.

1. Bailey, Edgar, and John C. Chiddix, *General Science Projects.* Science Publications, Normal, Illinois, 1950.
2. Chiddix, John C., *Chemistry Projects.* Science Publications, Normal, Illinois, 1949.
3. Cook, Sherman R., *Electrical Things Boys Like to Make.* The Bruce Publishing Company, Milwaukee, Wisconsin, 1942.
4. Davis, Helen Miles, *Science Exhibits.* Science Service, Washington, D. C., 1955.
5. *Encouraging Future Scientists: Keys to Careers.* Future Scientists of America Foundation of The National Science Teachers Association, 1201 16th St., N.W., Washington 6, D. C.
6. *Encouraging Future Scientists: Student Projects.* Future Scientists of America Foundation, National Science Teachers Association, 1201 16th St., N.W., Washington 6, D. C.
7. *Experiments with Light: Practical Problems for Students in Science.* Illuminating Engineering Society, 51 Madison Ave., New York.
8. *If You Want to Do a Science Project.* Future Scientists of America Foundation of The National Science Teachers Association, 1201 16th Street, N.W., Washington 6, D. C.
9. Ingalls, Albert G., *Amateur Telescope Making.* Munn and Company, Inc., New York, 1946.
10. *Laboratory Experiments with Radioisotopes for High School Science Demonstrations.* Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.
11. Richardson, John S. and G. P. Cahoon, *Methods and Materials for Teaching General and Physical Science.* McGraw-Hill Book Company, Inc., New York, 1951.
12. *Science Teaching Ideas* I & II. National Science Teachers Association, 1201 16th St., N.W., Washington 6, D. C.
13. *Thousands of Science Projects.* Science Clubs of America, Science Service, 1719 N St., N.W., Washington 6, D. C.

> **RECOMMENDATION**
>
> Science teachers should modify their methods of evaluating a student's progress in the light of all objectives of science teaching and should give particular attention to the contributions of projects.

Ideas for Student Projects

POLLEN ANALYSIS AND DETECTION OF ALLERGENS

Make permanent slides of pollen grains which are allergens. Use these slides to learn to recognize allergens in mixed-pollen slides. Steps in preparing these reference slides are as follows.

Place a small amount of the pollen on a clean microscope slide.

Add two drops of concentrated KOH solution. Warm gently over a low flame.

Add successively drops of water and succesively remove with absorbent paper until KOH is mostly removed.

Add a drop of glycerin jelly and place cover slip, allowing glycerin jelly to spread evenly.

To make slides for an analysis of the pollen content of the air, coat lightly with a film of vaseline and expose in an open, outside place for a 24-hour period. The slides are then collected, marked off into squares and counts are made. The counts can be used to predict increased incidence of hay fever or for determining vacation areas to which hay fever sufferers might go.

Related experiments:

Studies of distances pollen is carried by winds

Studies of plant succession during growing season

Extraction of pollen from peat bogs (see next project description)

Use of pollen grains as indicators of geologic age

BIOCHEMICAL POLLEN RESEARCH

Projects based on the following suggestions encourage students to progress from a simple experiment in pollen identification to:

Determination of the kind and age of vegetation in peat bogs and fossils

The correlation of the presence of certain plants and oil-bearing deposits in the earth

Searching for a solvent for the pollen capsule (since none is now known)

Start with pollen obtainable from local sources. Proceed to the extraction of pollen from peat, coal, and fossils if desired.

Procedure: To 2 cc of peat add 200 ml of water, ten drops of concentrated KOH solution, and three to five drops of Gentian violet stain. Boil gently for five to 15 minutes, stirring constantly. Filter and wash through a wire sieve or cheesecloth with distilled water until the volume of the filtrate is about 400 ml. Centrifuge or let filtrate stand until separation is complete. Mount on glass slides by adding one or two drops of glycerin jelly to the pollen and cover with cover slips.

To prepare glycerin jelly, use 28 g of gelatin, 166 ml of glycerin, 196 ml of water, and 4 g of phenol. Dissolve gelatin in water, add other materials, and boil gently for five minutes.

Reference: Spore Analysis Manual. California Research Corporation, La Habra, California. Also, Dr. H. P. Hansen, Dean of the Graduate School, Oregon State College, Corvallis.

PRODUCTION OF PLANT MUTATIONS BY COLCHICINE

What are some effects of colchicine on growing plants? How may such effects be controlled and used? Questions like these can trigger a long chain of intriguing student projects. *Caution:* Colchicine is an active poison. It may cause skin irritation if handled too freely without rubber gloves; it is very damaging to the eyes.

Alternate techniques for studying colchicine effects are as follows:

Mix 1 g of colchicine powder with 100 g of lanolin. Apply resulting salve to growing points of test plants.

Soak seeds in a solution of 0.5 g of colchicine in 1 pt. of water.

Mix colchicine with glycerin, water, and alcohol. Apply to growing seedlings with a brush.

Invert a bundle of seedlings into a jar of 0.1 per cent colchicine solution—growing points downward—just deep enough to submerge growing point and axial buds. Place battery jar over all.

The use of control plants in the above experiments is obvious. Concentrations can be varied experimentally with all methods.

EFFECTS OF STREAM POLLUTANTS ON LIFE IN THE STREAM

Research scientists do not have all the answers as to how stream pollution influences fish and other life in a stream. Does the pollutant kill the fish directly? Or does it use up oxygen and thus suffocate the fish? Or does it interfere with the food cycle that feeds the fish? How tolerant to

pollution are different kinds of fish? Other forms of stream life? What is the effect of stream velocity on the effect of pollution?

Student projects based on questions like those above can be designed and carried out using aquaria or troughs or glass tubes through which water is made to flow and into which the forms of life and the pollutants can be introduced. Related studies can be made of stream conditions and pollution in the student's own locality.

LEGUMES AND NITROGEN-FIXING BACTERIA

A good project can grow out of a comparison of different legumes for the production of nodules containing nitrogen-fixing bacteria. The growth of nodules can be observed if each legume is grown in a large test tube or slender pickle jar containing an inch or two depth of nutrient agar medium. The seeds, preferably sterilized, should be placed directly into the agar which has been inoculated with the nitrogen-fixing bacteria. A stopper prevents loss of water, but there should be a small hole in the stopper to permit an exchange of gases.

Related projects:

Microscopic or photomicroscopic work with nitrogen-fixing bacteria

Identification of kinds of nitrogen-fixing bacteria

Analysis of protein content of different legumes

Use of agar medium to grow different kinds of plants to observe types of root structures

RADIOISOTOPES

Radioautographs present an excellent method of studying radioactivity and may be used where Geiger counters are not available. Grow several bean plants in a nutritive solution that is phosphorus-free. Order radioactive phosphorus to be delivered at the time the plants are four to six inches tall. Introduce a small quantity of P^{32} into the nutritive solution; let stand overnight. Place upper stem and leaves in contact with photographic film. Expose from one hour to several days. Develop film in usual manner.

Repeat the experiment with a second plant that has remained in phosphorus solution for three additional days. Note any changes in location of phosphorus. Take a third specimen at this time. Remove it from nutritive solution which is free of phosphorus; let stand for three days. Make a radioautograph of the third plant and note the location of the phosphorus. Let one plant mature in P^{32} solution. Check for absorption of P^{32} at time of maturity. Repeat experiments with other plants. Use four tomato plants and put them in P^{32} at different stages of growth to see at what age the tomato plants take up the most P^{32}. This experiment can be extended to include other radioisotopes.

Reference: Laboratory Experiments with Radioisotopes for High School Science Demonstrations. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 25¢.

DEMONSTRATION THAT PROTOZOA LIVE WITHIN THE INTESTINE OF A TERMITE

With forceps, hold the termite by the anterior portion and gently press the abdomen with a dissecting needle until the intestinal fluid is forced out. Place a small quantity of the fluid on a slide to which a drop of water has been added. The student may wish to search for answers to the following questions.

What protozoa are present?

Can a termite live after the protozoa have been removed?

Can protozoa be cultured outside the body of the termite?

Can the protozoa be cultured and made lethal to control termite infestation?

REGENERATIVE POWERS OF THE EARTHWORM

Very little is known of the extent of regeneration that can occur in the earthworm. This project requires consideration of variables, such as species of worm, climate, temperature, and number of segments removed. This is an area of investigation in which there has been very little research to date. Continued study and research may lead to the eventual discovery of new knowledge concerning regenerative power of animal cells.

Related projects:

Regeneration in other animals such as the starfish, salamander, and planaria

Comparison of regenerative powers of two kinds of worms

THE EFFECT OF TESTOSTERONE ON THE COMB GROWTH IN CHICKENS

Use four chickens ranging from one day to two weeks old. Set up two groups of chicks, of two each, with one group for treatment and the other for a control. Either testosterone or testosterone propionate in oil solution is suitable to work with, concentrated to about 10 mg per ml. Inject the

chick under the skin at the back of the neck once daily for eight days. At the end of eight days, measure the comb of the experimental chicks with that of the control chicks.

VIRUS IN CIGARETTES

Plant bean seeds about two weeks before inoculation. When plant is ready to be inoculated, dust the surface of the leaf with 400 mesh carborundum powder. Crush some cigarette tobacco in a small amount of water and rub some of this liquid on the leaf surface. Wash the inoculated area with water. If tobacco mosaic virus is present, small round black spots will appear on the inoculated area.

This project can be carried further by determination of

- Effect of heat on virus concentration (50-90° C)
- Effect of dilution on virus solution
- Effect of various abrasives
- Effect of using no abrasive
- Effect of using different methods of inoculation, such as brush, needles, or atomizer

A student may wish to show that some potato plants carry a plant virus in a latent condition. To do this, the student may mash the leaves or sprouts of a potato and inoculate a tomato or pepper plant with the juices obtained.

Reference: Smith, Kenneth M., *Recent Advances in the Study of Plant Viruses,* Second Edition. The Blakiston Company, Philadelphia, Pa., 1951.

SURFACE STERILIZATION OF FOOD BY X RAYS

Recent research has shown that the shelf life of fresh produce can be lengthened by exposure to X rays. If such food is sealed in this transparent wrapping material and is exposed to X rays, answers to the following may be determined.

To what extent is the shelf life increased?

Is the process commercially feasible?

What are the effects of temperature on radiated food?

Are there discernible effects from such foods when used in animal nutrition?

THE ABILITY OF WOOD TO WITHSTAND STRESSES

Problems in wood stress analysis include breaking point comparisons, elasticity studies, residual "set" limits, and comparative rigidity.

The breaking point of wood depends on many variables including the species, water content, grain, fabrication (i.e., I-beams), size, and shape of pieces. "Set" means the permanent bend a piece of wood takes due to overloading. A student can choose one variable subject, such as loading the wood to the breaking point, and compare the results when different samples are used. All the variables must be kept constant except the one under study.

Elasticity studies require a slightly different treatment. A meterstick fastened to a non-movable surface can be used to measure sway under different loads.

Although a student may investigate any of these problems without using established data, an interesting problem would be the testing of such data to determine their validity.

RELATION BETWEEN MINERAL CONTENT OF SOIL AND MINERAL CONTENT OF PLANTS GROWN IN IT

For a given crop, such as apples, carrots, potatoes, or spinach, does the amount of a certain mineral contained in the soil make a difference in the amount of this mineral taken up during growth of the crop?

Procedures for projects based on this problem can be developed through reference to textbooks of agricultural chemistry and food chemistry and food analysis.

RADIOISOTOPE TRACERS

Radioisotopes of phosphorus, sulfur, carbon, iodine, and other elements, to be used for experiments on plants and animals, can now be obtained in quantities up to ten microcuries from authorized sources. P^{32} can be added to water in the soil around plants such as tomatoes, beans, or squash. A Geiger counter will show that P^{32} has moved up into the leaves. Further evidence can be gained by placing the plant on X ray film until a radioautograph is made. This experiment may be varied to show that materials are carried both up and down by feeding P^{32} in water through a wick inserted into a slit in the stem. Many variations may be worked out with various plants and tagged elements. Possible problems are in the uptake of fertilizer, soil fertility, insecticides, herbicides, photosynthesis, and pathology. In animals the presence of phosphorus in the bones of fish may be shown by adding P^{32} to the aquarium.

Mutations in organisms such as Drosophila may be induced by exposure to a cobalt-60 source available at a nearby institution. For further suggestions see: *Laboratory Experiments with Radioisotopes for High School Science Demonstrations.*

Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 25¢.

COMPARISON OF NERVOUS SYSTEMS OF ANIMALS WITH CONTRASTING METABOLIC RATES

The nervous system of an active specie of lizard can be contrasted with that of an inactive specie of lizard. The nervous system of a small turtle can be compared with that of a small bird.

The following technique produces an almost transparent animal with a stained nervous system.

Place the dead animal in 95 per cent alchohol for 48 hours. Transfer to solution No. 1 for one to three days (preparation of solution is described below). When transparent, place in solution No. 2 for 72 hours, then in solution No. 3 for a week. Remove stain by placing in solution No. 2 again for 18 hours. Store in glycerin.

Solution No. 1—Potassium hydroxide, 1 per cent aqueous solution

Solution No. 2—Glacial acetic acid, 1 part
Glycerin, 1 part
Chloral hydrate, 1 per cent solution, 6 parts

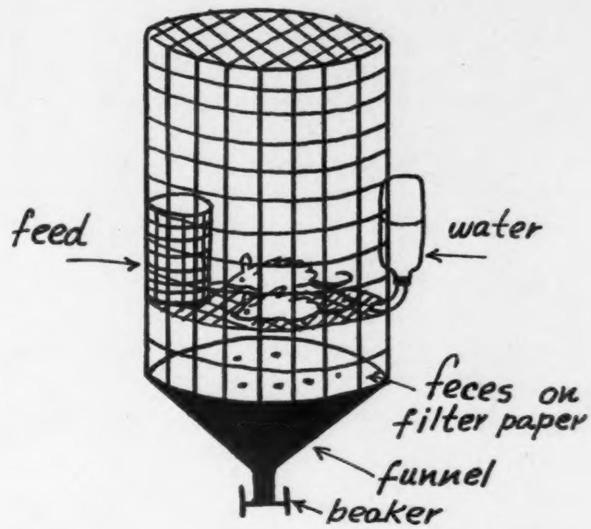
Solution No. 3—Glycerin, 1 part
Ehrlich's acid hematoxylin, 1 part
Chloral hydrate, 1 per cent solution, 6 parts

A slightly different technique may be used to prepare transparent specimens with differential staining of bone or cartilage tissue. Alizarin red-S will stain only calcium deposits while methylene blue will stain only cartilage. Other dyes such as yellow India ink may be used in place of the alizarin red-S. Scales must be removed prior to staining bone tissue.

References: Hollister, G., "Clearing and Dyeing of Bone in Fish," *Zoologia,* Vol. 12, No. 10, 1934. Lipman, H. J., "Staining and Clearing of Embryos," *Stain Technology,* Vol. 10, No. 2, 1935. Richmond, G. W. and Leslie Bennett, "Clearing and Staining of Embryos for Demonstrating Ossification," *Stain Technology,* Vol. 13, No. 2, 1938.

A STUDY OF THE DIGESTIBILITY OF A CEREAL PRODUCT AS MEASURED WITH RATS

Rats have nearly the same digestive powers as humans. This study is an attempt to determine the percentage of digestibility of dry matter in a cereal such as Cream of Wheat. A cage may be constructed of 3/8" wire screen. Two white rats, two males or two females (preferably the former), can be used. Cream of Wheat is placed in an 8-oz., wide-mouth bottle placed inside a close fitting wire screen cylinder attached to the cage to prevent tipping and spilling. Rats must feed head down thus reducing error since food is brushed off as the rat withdraws from the feeding bottle.



It is best to start this study on a Friday. At that time rats are taken off their regular diet (poultry ration is good) and placed on Cream of Wheat. Two days are usually sufficient for the new diet to appear in feces. A dye or radioactive salt might be used to pinpoint the exact time. Dried food (heat to 130° C in drying oven for two hours to expel H_2O) is weighed accurately. About 200 g are sufficient for a one-week study. At the end of one week, the remaining food is dried and weighed to determine, by difference, the intake portion. The output (feces) is collected on filter paper resting on a window screen a few inches below the main cage. The feces is dried and weighed. The intake minus output equals the digested nutrients and may be easily converted to per cent. Analysis methods of the Association of Official Agricultural Chemists are used.

References: Official Methods of Analysis of the A.O.A.C. Association of Official Agricultural Chemists, Washington 4, D. C.

Bulletin #675. Texas Agriculture Experiment Station, College Station, Texas.

FLATWORM PARASITES

Interesting investigations with flatworm parasites and their complex life histories may be made in areas where snails and crayfish are found in

streams. For example, a Trematode has been found in a certain snail (cercaria and sporocust stages), crayfish (metacercaria stage), and mink (adult stage). Experimentation also shows that the adult stage will develop in hamsters if they are fed infested crayfish. Eggs found in the feces are used as an indication of infection. Other parasites such as that causing "swimmer's itch" may also be studied. Related species may be found in the intestines, lungs, or liver of frogs, turtles, and raccoons. The life histories of many of these have not, as yet, been completely determined. These studies may be aided by a variety of staining and slide making techniques.

Reference: Macy, Ralph W. and Donald J. Moore, "On the Life Cycle and Taxonomic Relations of Cephalophallus Obscurus N.G., N.Sp.," *The Journal of Parasitology,* Vol. 40, No. 3, June 1954.

USE OF SEROLOGY TO ESTABLISH RELATIONSHIPS AMONG INSECTS

By the use of chromatographic analysis or electrophoretic techniques, hemolymph samples from various species of insects can be compared on the basis of the intensity and width of the bands formed. Two-dimensional chromatography involves the use of different solvents.

Related experiments:

Establishment of relationships among other organisms

Analysis of amino acids in substances

Analysis of metallic content of plant juices

Analysis of metallic content of soil samples

Reference: Block, Richard J. and others, *Paper Chromatography and Paper Electrophoresis.* Academic Press, Inc., New York, N. Y., 1955.

THE CONSTRUCTION, CALIBRATION, AND USE OF A THERMOCOUPLE IN DETERMINATION OF THE MELTING POINTS OF VARIOUS METALS

A student may construct a thermocouple of the constantin-iron type and use known points such as the boiling point of water and melting points of tin or lead to calibrate the thermocouple with reference to the potential in millivolts. It is proper to have the cold junction of the thermocouple placed in an ice bath at 0° C. The resulting data can be plotted as a straight-line graph passing through zero centigrade and zero millivolts. A reading in millivolts can then be converted to temperature by referring to its location on the graph and finding its intercept on the temperature axis. The thermocouple may be used to investigate the melting points of various alloys. In general, this method will give very satisfactory results with a Bunsen burner provided that the temperature does not exceed 350° C.

WHAT IS THE RATE AT WHICH SODIUM NITRATE LEAVES THE TOP FOOT OF SOIL?

Materials: Five glass cylinders 1 foot long; soil of the same type for all containers; sodium nitrate; distilled water.

Directions: Fill each cylinder to the same level with soil. Apply 10 g of sodium nitrate to the surface of each container of soil. Apply distilled water daily to each container in the following amounts: 100 ml, 200 ml, 400 ml, 600 ml, 800 ml. Measure and record the volume of water that drains from the soil cylinders each day.

Test the water solution from each container daily for nitrates.

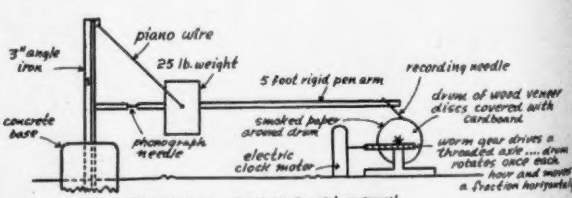
Continue application in each container until a nitrate test does not show the presence of a nitrate.

Make a graph of time and volume of water used in each tube.

Write a summary of your findings and report your project to the class.

DETECTING EARTHQUAKES BY HOMEMADE SEISMOGRAPH

Once the following device is constructed and in operation it demands little attention. One visit a week for the purpose of changing record sheets on the recording drum will often suffice. The housing may be in almost any out-of-the-way place such as a basement corner or on the soil under a school building. The major cost will be about $5 for a good electric clock motor. All other materials can normally be obtained with a minmum of expense.



HOME MADE SEISMOGRAPH SKETCH

In normal quiet operation, the needle will mark straight lines around the drum. When an earthquake wave reaches the seismograph, the whole instrument moves. The heavy weight, suspended as a pendulum, tends to stand still because of its inertia. Thus, in normal recording, the center of

gravity of the weight acts as the fulcrum of a lever extending from a phonograph needle support to the recording needle resting on the smoked drum. In this way the earth wave causes the long pen arm to scratch a greatly magnified graph of the actual intensity of the wave on the smoked paper.

Reference: Scientific American, February 1939.

PERMANENT OR SEMI-PERMANENT SLIDE COLLECTION OF GROSS STRUCTURES

Slides of materials which do not require the use of specialized cutting devices or elaborate staining in their preparation can be made of the following.

Parts of insects such as legs, wings, and eyes
Whole micro-organisms
Very small insects such as fleas
Pollen
Epidermal cells of plant organs

A mounting medium can be of white Karo syrup for specimens that will not suffer from plasmolysis. Slightly more specialized processes will be required for those that do. Karo slides will last from three to five years. Balsam will last indefinitely.

CONTROLLING GERMINATION TIME OF SEEDS

Germination time of some types of seeds can be shortened or the percentage of germination can be increased by one or more of five standard treatments. These are:

Mechanical scarification (notching through the seed coat)

Cold treatment (keeping the seed at or near freezing temperatures, from 1° to 5°, for weekly periods varying from one to four weeks)

Soaking in concentrated sulfuric acid (for periods of five to 60 minutes at five-minute intervals)

Soaking the seed in water (for periods varying from 12 hours to one week at 12-hour intervals)

Determining the optimum length of time for each treatment for various kinds of seeds may form a good student project. All treatments should be planned to end at the same time so that planting and cultivation need not vary and therefore be considered as additional variable factors.

Types of seed to try include white clover, sweet pea, red beet, delphinium, and castor bean.

PHOTOMICROGRAPHY—A TOOL FOR THE STUDENT-SCIENCE PROJECT

When a student chooses a problem of a microscopic nature, his progress might better be reported with the aid of photographs taken through the microscope.

The popular 35-mm single-lens reflex camera can be attached to a microscope by using an inexpensive coupling (sold in most camera stores). Similar couplings can be designed by the student for a box camera.

Correct exposure depends on the film speed, light source, magnification, and material being photographed. Reflected or dark-field techniques require brighter light than the usual transmitted light methods. A graph or table can be developed to aid approximating exposure for the various conditions anticipated in the project. Such a table speeds up and simplifies photomicrography.

These subjects photograph well: algae, bacteria, molds, protozoa, rotifers, daphnia, micro-sections of plant and animal tissue, crystals, etched metal alloy surfaces, fibers of cloth or paper, and blood cells.

With practice, excellent results can be obtained and fine-grain prints enlarged to 8 x 10″. Color prints are especially rewarding but are quite expensive.

COMPARATIVE VERTEBRATE SKELETONS

Typical vertebrates such as the mouse, rat, rabbit, chicken, fish, snake, and frog may be obtained. As much of the flesh as possible must be removed. Place the skeletons on an ant hill or in a crock full of water. If placed in the water, they should remain for about five days. At the end of this time the remaining flesh should be cut off and the bones scraped. Be careful not to remove the cartilage or ligaments. The skeletons should then be degreased by placing them in a solution of acetone or xylol for a few days. They should then be bleached by placing them in a solution of three per cent hydrogen peroxide for 24 to 48 hours.

Bones which come loose can be restored to their proper places by the use of fine copper wire and a small drill or by gluing with a clear plastic glue. The skeletons should then be mounted on plywood boards. Each variation or comparison can be made by running ribbons or string from the variation to a key on the boards.

CANCER PRODUCED BY VIRUS

Cancer can be produced by different types of chemical compounds and a few viruses. The latter materials are produced in living organisms. One of these viruses, the Raus sarcoma virus, is a tumor-producing agent which is highly specific for chickens.

Use chickens three to four weeks old. Make the injection at the anterior feather-free surface of the wing or wing web. Swab the wing with 70 per cent

alcohol prior to the injection. Pass the needle through the skin into the desired site and inject .2 to .5 ml of the virus suspension. Beginning the fifth day after inoculation, the site on each chicken should be examined daily for the appearance of a small raised nodule.

Reference: Lyophilized virus is available in ampules from the American Type Culture Collection, 2129 M St., N. W., Washington 6, D. C.

DETERMINATION OF THE GLYCOGEN CONTENT OF THE LIVER OF HIBERNATING ANIMALS

Test small animals that hibernate for the glycogen content of the liver. It will be necessary to run the tests in the fall, winter, spring, and summer if the findings are to be considered valid.

Special care and consideration should be given to the matter of selection of animals and to the methods employed in killing them. To harm or kill an animal which is protected by state and federal regulations is punishable by fine and possible imprisonment. It is an inviolable rule that experimental animals must receive humane treatment in the laboratory.

After the liver has been removed, grind it in a mortar using fine sand. Add water, place in an evaporating dish, and boil for 20 minutes. Note the appearance of opalescence. When the substance in the evaporating dish reaches the boiling point, acidify it faintly by adding a few drops of nitric acid. Filter to obtain at least 5 ml of filtrate in a test tube. Add five to ten drops of iodine solution and two or three drops of ten per cent sodium chloride. A reddish, port-wine color indicates the presence of glycogen.

Glycogen is an important constituent of muscle tissue and may be prepared from muscle by extracting it with boiling water and then precipitating the glycogen from the aqueous solution with alcohol.

Variations in the glycogen content of liver and muscle of animals may also be tested after periods of overfeeding, normal feeding, starvation, exposure to cold, and other environmental factors. Changes in glycogen content of the liver because of nervous influences could also be explored.

THE STUDY OF MENDELIAN LAWS USING DROSOPHILA

The principles of Mendelian inheritance can be illustrated in a comparatively short period of time by the use of Drosophila (fruit flies). This organism is easy to work with, requiring a minimum of care and equipment. Many students have raised more than enough fruit flies for experiments by hatching them in a covered jar containing an overripe banana.

The genetics department of practically every college or university has one if not more cultures of fruit flies. They are relatively inexpensive when purchased from biological supply houses.

Examples of some of the types of experiments would include crossbreeding to obtain new strains, breeding back to illustrate the laws of dominance, and treatment of flies in an attempt to produce mutations.

References: "Turtox Service Leaflet No. 15," General Biological Supply House, 761-763 East 69th Pl., Chicago 37, Ill.

Demerec, M. and B. P. Kaufmann, *"Drosophila Guide."* Carnegie Institution of Washington, 1530 P St., N. W., Washington 25, D. C., 1950. Price 25¢.

DETERMINATION OF THE RELATIVE AMOUNTS OF THE CONSTITUENTS OF WOOD

Determine the relative amounts of carbon, oils, tar, water, and nitrogen-free materials in various types of wood. Compare the relative amounts of each of the above as found in the different parts of one tree: conifer branches or cones as compared to trunk or root wood.

Condition samples of the wood for a specific length of time to reach similarity of water content. Break down each sample by the use of destructive distillation. Compare the weights of all the apparatus before and after heating, such as delivery tube, test tube or bottle, and drying tube. Construct a bar graph or similar tool showing the fractions obtained by this process. Account for any apparent loss of total weight.

By adding measured amounts of solvent, more precise separation of oils might be obtained in the distillation process. The value and use of the products may prove of additional interest to students.

Another investigation with practical teaching value is exposing several kinds of wood to the weather for several weeks and determining the effects produced. To determine the desirability of a specified type of wood as building material in humid areas, compare the rates at which the various types of wood absorb water when the specimens are weathered.

AN INVESTIGATION IN METALLOGRAPHY

Obtain a variety of metals which are easily polished. The metals should be of a type which

reveal their crystalline structure when etched by a material which causes differential action on them.

The goal of the polishing process is to produce a surface showing no scratches under a microscope which magnifies 100 diameters. The first steps may be to cut the metal into small squares. Then level the squares with a file, sand them with an abrasive such as flint or carborundum paper, and polish them with crocus cloth and jeweler's rouge.

When you have etched the samples of each type of metal, compare them under a magnification of 100 diameters. What are the differences in crystal structure? Are there actually cracks in the metal or is it just a discoloration which brings out the crystalline structure of the metal? These and other questions will arise. As the answers are determined they should be recorded and made available to other members of the class for their study.

PREPARATION AND LIQUEFACTION OF GASES

(Note: Don't be caught off guard; use every safety precaution available in a project of this type.)

Here is a problem-solving laboratory project which gives personal meaning to ideas and information given as facts in textbooks and other reference sources.

Common gases with boiling points in the intermediate range, such as ammonia, chlorine, butane and sulfur dioxide, are prepared or collected using standard preparations as outlined in most laboratory manuals. The gas is led through a standard drying tube containing a drying agent. The gas is then passed into a condensing tube surrounded by dry ice. The condensing tube may be standard glass tubing prepared as a spiral for greater effectiveness. The length of the condensing tube and rate of flow of gas must be adjusted to make sure that the change from gas to liquid state is complete within the condensing tube. The liquid may also be collected in short metal cylinders immersed in dry ice. A suitable cylinder may be prepared from scrap copper or galvanized iron pipe with a cap at one end and threaded for capping at the other end. A standard laboratory gas jet and valve may be incorporated as part of the collecting cylinder to allow for later testing of pressures at controlled temperatures.

Some suggested topics for investigation are

Comparison of weight of gas collected to theoretical yield for quantities of chemicals used

Quantities of dry ice needed for liquefaction of different gases under various conditions

Gas pressures within cylinders (not necessarily the ones above) at controlled temperatures

Cooling effect of the expansion of gases such as the principle at work in most modern refrigerators

Because of the many facets of this problem, it is possible it will lead the student to further experimentation in this area.

PHYSICAL CHANGES WHICH OCCUR DURING DEHYDRATION OF FOOD

Materials necessary for the following project are cabbage, sodium bisulfite, a kraut slicer, wooden spoon, stainless steel basket, balance, knives, and trays and tags for labeling.

Directions: Wash, trim, and slice cabbage ¼ in. thick. Divide into four lots and treat in the following manner:

Lot I: No treatment.

Lot II: Dip in 0.6 per cent sodium bisulfite solution for one minute and drain. (Use nine liters of water in a 30 lb. can. Add calculated amount of sodium bisulfite and trace of acetic acid.)

Lot III: Steam blanch four minutes.

Lot IV: Steam blanch four minutes and dip in 0.6 per cent sodium bisulfite solution for one minute and drain.

Spread each lot on a tray immediately, label, and place in preheated dehydrator. Place an empty tray on top of each loaded tray. Set the dry bulb thermometer at 145° F.

Laboratory instructor will remove the products from the dehydrator and store for future observations.

Note the odors of the cabbage prior to rehydration performed as follows: Add 400 ml of water to 600 ml beaker plus ¾ tsp of salt, cover with a watch-glass, and bring to a boil. Add 30 gs of dehydrated cabbage, turn down the flame, and simmer for 40 minutes.

Determine the drained weight and calculate the per cent increase in weight. Examine as to color, flavor, texture, and general acceptability.

Although this project seems like a traditional laboratory exercise in food technology, it provides the student with a number of related opportunities for peripheral investigations. The restoration of physical properties of many other foods can be attempted. The use of food coloring, seasoning, and other materials may be employed.

Thank You . . .

to the many persons who helped make the 1956 West Coast Science Teachers Summer Conference a success. First, to the members of the Development Committee who shared in the design of the conference and faced up to the difficult problem of reviewing more than 100 applications and selecting the Fellows:

Mrs. Anita Bickford, Teacher of General Science, Leland Junior High School, Chevy Chase, Maryland; Dr. Kenneth E. Brown, Specialist for Mathematics, U. S. Office of Education, Washington, D. C.; Dr. Hiden T. Cox, Executive Director, American Institute of Biological Sciences, Washington, D. C.; Dr. John R. Mayor, Director, Science Teaching Improvement Program, American Association for the Advancement of Science, Washington, D. C.; Dr. Ellsworth S. Obourn, Specialist for Science, U. S. Office of Education, Washington, D. C.; Dr. B. R. Stanerson, Assistant Executive Secretary, American Chemical Society, Washington, D. C.; and Dr. John H. Woodburn, Assistant Executive Secretary (formerly), National Science Teachers Association, Washington, D. C.

Next, to members of a large Advisory Committee who, through laborious and involved correspondence, reacted to plans proposed by the Development Committee: Dr. J. W. Buchta, University of Minnesota, Minneapolis; Dr. Gertrude W. Cavins, San Jose State College, California; Mr. Thomas A. Clark, Baldwin Park, California, High School; Mr. Richard C. Date, San Francisco, California; Mr. Gordon R. Hjalmarson, Huntington Beach, California, High School; Miss Virginia F. Kent, Seattle, Washington; Mr. Dewey E. Large, American Museum of Atomic Energy, Oak Ridge, Tennessee; Dr. Harry F. Lewis, Institute of Paper Chemistry, Appleton, Wisconsin; Mr. Lorenzo Lisonbee, Phoenix, Arizona; Dr. W. H. Myers, San Jose State College, California; Dr. Nathan S. Washton, Queens College, Flushing, New York.

Another, very important group of contributors has already been identified—the visiting lecturers—to whom we are greatly indebted.

Two full days of the conference were devoted to laboratory visitations and interviews with scientists on the staff of Oregon State College. We are grateful, indeed, for the time and help of the following who discussed the topics indicated: Dr. Campbell M. Gillmore, "Research in Bacteriology"; Dr. Jerome J. Brady, "Internal Friction of Metals"; Dr. LeMar F. Remmert, "Metabolism of Carbohydrates"; Dr. Louis N. Stone, "High Voltage Electricity"; Dr. Howard H. Hillemann, "Animal Breeding Experiments"; Dr. Lois A. Sather, "Research in Food Technology"; Dr. Vernon H. Cheldelin, "Research Methods in Biochemistry"; Dr. Henry P. Hansen, "Techniques of Pollen Analysis"; Dr. Ernst J. Dornfeld, "Physiology of Cell Movement"; Dr. David S. Stevenson, "Insect Transmission of Disease" and "Blood Relationship of Insects"; Dr. Fred W. Decker, "Research Projects in Meteorology"; Dr. Jesse S. Walton, "Research Projects in Chemical Engineering"; Dr. John B. Grantham, "Wood Products Laboratory"; Dr. Jefferson B. Rodgers, "Hay Drying and Manufactured Hay"; Dr. John P. Riley, "Sprinkler Irrigation Research"; Dr. Charles E. Warren, "Research in Water Pollution"; Dr. Paul O. Richter, "Teaching Aids in Entomology"; Dr. Edward C. Bubl, "Radiation Sterilization"; Dr. Sheng Chung Fang, "Use of Radioisotopes in Agriculture Chemistry"; Dr. Paul H. Weswig, "Nutritive Evaluation of Pasture Grasses"; Dr. Gordon F. Snow, "Research in Plant Viruses"; Dr. Ivan W. Buddenhauen, "Research With Fungus Disease".

Thanks, also, to the management and staff of the following industrial establishments who provided interesting and informative tours for the conference Fellows: the Crown Zellerbach Corporation plant at Camas, Washington; the Alcoa plant at Vancouver, Washington; and the U. S. Bureau of Mines Station at Albany, Oregon.

Finally, but by no means least in degree of appreciation, the conference Fellows sincerely thank the Crown Zellerbach Foundation for providing the financial support to make this conference possible; and they extend congratulations and appreciation to the National Science Teachers Association and to Oregon State College for the foresight, leadership, and facilities so essential to success in an undertaking of this kind. Were the Fellows to make a capstone recommendation, it would be this:

We recommend that the West Coast Science Teachers Summer Conference be continued along the lines of the 1956 conference. Definitely a service to science teachers of the region, it is even more so a service to and an investment in the science students these teachers work with and among whom are many of tomorrow's scientists, engineers, and technicians.

HIGH SCHOOL PHYSICS IN POPULAR DRESS

By CARLETON J. LYNDE

Professor Emeritus of Physics, Teachers College, Columbia University, New York

CAN PHYSICS EARN the title of The Most Popular High School Subject?

My answer, on the basis of nine years as a high school physics teacher and 37 years as a teacher of beginning college classes in physics, is a firm, "Yes," *providing* that two comparatively simple changes are made.

The chief barrier to physics' popularity, it seems to me, is the high school laboratory work. This is essentially the first-year college laboratory course shoved down into high school. The assumption is that laboratory work designed for college students who intend to specialize in physics is also the proper laboratory work for boys and girls who have just come up from the elementary schools into high schools. "This is just not so," is my strong conviction—as a result of my own teaching experiences.

These are the two simple changes which I suggest teachers can make to win popularity for physics courses.

First: Do the present laboratory work *in the classroom* as demonstrations. The students, in turn, will make the measurements, under your supervision. Those in their seats will make the calculations, with your help, and enter the results in their notebooks.

Second: Have the new work in the laboratory consist largely of *home experiments;* that is, short experiments which the boys and girls can repeat, over and over, with things in the home and things from local stores.

As a college physics teacher, I taught students of agriculture, home economics, and nursing. Each group, of course, required special training in their own field, but all the students needed some instruction in each division of physics. Consequently, part of the laboratory work, which I was free to choose, was the same for all. It consisted chiefly of a variety of home experiments.

This was the usual procedure: Ten home experiments were demonstrated in the classroom, with the students, in turn, doing the demonstrating. For the next laboratory period, the ten home experiments were set up in the laboratory. The class was divided into ten groups; each group did all the experiments, in turn, at five-minute intervals. Most important, no written reports were required to be made.

These physics college courses were required work and many students entered the class dreading physics. But, as a result of the home experiments, most of the students left the class with the conviction that physics is a very interesting subject. The results with home experiments in high school should be similar.

When you transfer the present laboratory work to the classroom, you can enrich it. For example, when you find the density of rock, you can also find the density of iron (spikes). When you measure the coefficient of expansion of brass, you can find it for glass (tubing). When you find the specific heat of lead, you can find it for sand. Many other similar experiments can be carried out.

When you plan home experiments. you may wish to increase your equipment. You can do this easily with the students' help, and, at the same time, increase their enthusiasm for physics. Two weeks before you plan to use the home experiments, demonstrate them in the classroom. As you finish each experiment, assign one or more students to bring in the needed equipment the next week; then have them demonstrate their home experiment before the class. The students will gladly leave the equipment in the school for the use of other students in future experiments.

Information, we all know, is not necessarily knowledge. Information is what we learn from others by seeing, reading, or hearing. Knowledge, on the other hand, is what we learn from our own experiences, using our minds and our senses. And if we repeat an experience again and again, the knowledge gained rarely leaves us.

Your students, who repeat home experiments over and over, at home, will acquire much knowledge of physics. Some will develop an intense interest in and enthusiasm for the science. They will talk about their home experiments, show them to classmates who are not taking physics. As a result, I predict, the number of physics students will increase each year, and, in time, physics may indeed become The Most Popular High School Subject.

THE HALLEY TERCENTENARY

By C. A. RONAN

Fellow, The Royal Astronomical Society, London

HALLEY'S COMET is not due to reappear for another 29 or 30 years, but Edmond Halley, the man whose name the comet bears, is very much in the public eye this year.

This British giant of the scientific world was born 300 years ago this month near London, on November 8, 1656, according to official records. In his 85-year life span—he died in 1742—he made great, new contributions to scientific knowledge and it is these achievements which are being recalled in the tercentenary of his birth.

Educated at St. Paul's School and at Oxford University, he boldly, at the age of 20, went to the island of St. Helena to observe the Southern Heavens. He was thus the first to make really precise observations of stars and other celestial objects which were invisible from observatories in the Northern Hemisphere. He also observed a passage of the planet Mercury across the sun's disk. As a result, he suggested that observations of Venus when it too appeared to cross the sun's disk could help determine the sun's distance from the earth.

A skilled mathematician, Halley applied Isaac Newton's theory of universal gravitation to the paths of comets. Comets had long attracted attention but only in the previous 100 years had they been recognized as truly celestial objects.

Halley observed that the paths of certain bright comets were very similar and he suggested that those which had appeared in 1531, 1607, and 1682 were in fact the same object. He went further and predicted this body would reappear in 1758. Halley was, of course, dead when the comet did return, but the world acknowledged his discovery and the comet has since been known as "Halley's comet." Its last appearance was in 1910; it is next due in 1985/6.

Halley became the second Astronomer Royal, succeeding the Reverend John Flamsteed in 1720. Before this appointment, he had held the Savilian Chair of Mathematics at Oxford. But the importance of these positions did not stop Halley from doing other scientific work.

He was interested in the saltiness of the oceans and suggested that examining the amount of saltiness should make it possible to estimate the earth's age. He discussed with great care the problem of trade winds, which were of vital importance in those sailing-ship days. He also did fundamental work on ocean currents and pioneered on statistics connected with human mortality. But astronomy always claimed his chief interest, and he discovered that the stars, which had been thought of as fixed in space, actually had individual motions of their own.

As a man, Halley seems to have been a delightful character, with a good sense of humor. It is also clear that he had "diplomatic" abilities of a high order. He was elected a Fellow of the Royal Society in 1678, became Assistant Secretary (a paid post) to the Society in 1686, and was elected Honorary Secretary in 1713. As a paid servant of the Society, he used his charm and tact to great advantage. This is particularly evident in the story of the publication of Newton's famous *Principia,* a book which has been called one of the great scientific treatises of all time.

Newton was never keen to publish his work, and it was after discussion with Sir Christopher Wren and Robert Hooke that Halley visited Newton in Cambridge and persuaded him to work again on his idea of universal gravitation. The result was the writing of the *Principia,* the printing and publication of which Halley paid for, and it was Halley also who undertook the tedious task of piloting the great volume through its various printing stages. In addition, he managed to get Newton to continue and complete the work when the latter wanted to leave it unfinished because of certain comments and criticism—a masterly example of Halley's tactful handling of what was a very delicate situation.

Halley's contributions to science were in many fields; in one instance, he ventured into the study of ancient Greek geometry and produced the first complete edition of the works of Apollonius. To the world at large, his fame stems from his cometary work which, in fact, was his main contribution. To those who have known him better through science studies, Edmund Halley is remembered 300 years after his birth as a great scientist in many fields, as a delightful man, and as one without whom the scientific world might well have lost one of its greatest books.

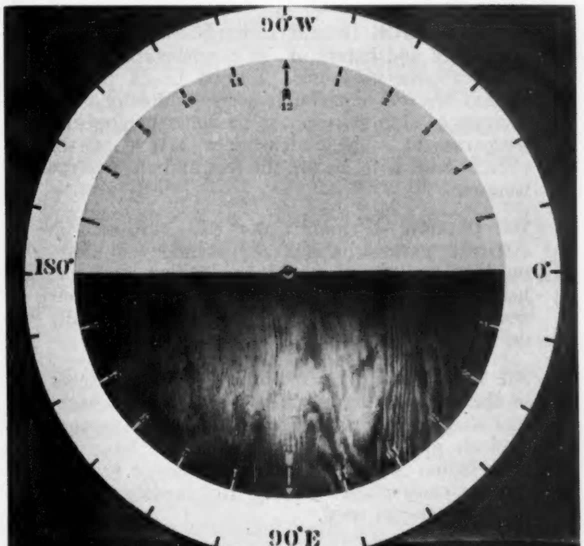
Classroom Ideas

General

Longitude, Time, and Date

By LELAND L. WILSON
Iowa State Teachers College, Cedar Falls

The relationship between longitude, time, and the date is often confusing to students encountering the subject for the first time. Textbook discussions of the topic explain that for westward travel the clock must be set back one hour for each 15 degrees of longitude and the calendar must be advanced one day on crossing the 180th meridian. Students often fail to realize that the calendar is set back a day at the point where the time is 12:00 midnight. These relationships are not easy to visualize since time undergoes continuous change and, as the point of midnight moves west, the part of the earth having a given date also changes continuously. The apparatus pictured here enables the student to clearly see the relationship between the longitude, time, and date.



The device consists of two large plywood disks. The larger one indicates longitude and each mark corresponds to the *center* of a time zone 15 degrees wide. The smaller disk indicates time with the daylight hours on the white half and the hours of darkness on the black half. The small disk is mounted on a bolt at the center so that it will turn and can be set at any position by tightening a wing nut.

Given the time and date at any longitude, one can determine the time and date for any other longitude at a glance. For example, one can see from the setting of the apparatus in the picture that if it is 12:00 noon on October 10 at 90 degrees W. longitude, it is 7:00 P. M. on October 10 at 15 degrees E. longitude and is 3:00 A. M. on October 11 at 135 degrees E. longitude. As the smaller disk is rotated counterclockwise, corresponding to the rotation of the earth, one can see the portion of the earth having the date October 10 getting smaller and that portion having the date October 11 getting larger. A few minutes practice with this apparatus will give the student a clear understanding of this problem and will eliminate the necessity for laborious blackboard diagrams.

Chemistry

An Ampule Reagent Rack for Semi-Micro Chemistry

By ROMAN R. CARR
Chem-Racks, Minneapolis, Minnesota

The thought that ampules can be used as an economical and convenient way of storing reagents and solutions led to the development of the rack described here. The 20-ml size was judged about right for the quantities required in semi-micro techniques. It was believed this would be a practical rack for use in both classroom and home laboratory work.

The shelves in the rack are first covered with foam rubber, then with polyethylene plastic sheet. In this way they are made to serve both as holders and closures for the containers. Although bottles may also be used, the chemically-resistant polyethylene presses firmly over the openings and makes stoppers unnecessary.

Many teachers have found that ampules may be substituted for the conventional dropping bottles

in most laboratory exercises. Because of the small openings and the surface tension of most solutions, the ampules can be used as droppers; the contents will not pour out in a steady stream even when completely turned over. The ampules can be used as droppers by simply inverting and tapping the bottom with the forefinger. Removed from the rack, the ampules should be held by their necks and given a slight downward pressure. When replaced, in similar vein, the bottom should be first inserted and pressed downward. Only one hand is required; the other is free to hold a test tube or graduated cylinder. In this method, it is possible that the number of "drops" may not be exact; however, most manual instructions for spot-testing will direct "one or two drops," "a few drops," etc.

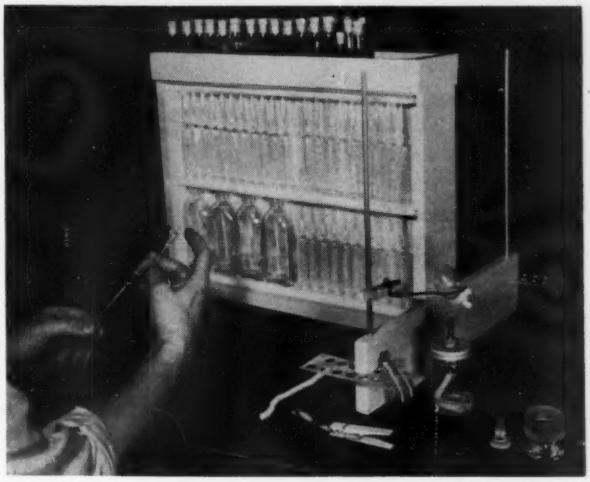
Procedures, of course, may be altered to read in terms of tenths of a milliliter or other metric unit of volume. Where more accuracy is needed, either five- or ten-ml graduates may be used or small pipettes, glass tubes, and capillaries. These may be filled readily by inserting tubes in the neck and tilting the ampule. The danger of drawing up caustic reagents in the mouth is thus eliminated.

The filling of ampules can be done, quite simply, by using a funnel with a rubber hose and a glass tube attached. The glass tube should be small enough for insertion in the expanded portion of the neck. The flow may be stopped at will by pinching the rubber with the fingers. It is convenient to fill a large number at a time; the stock bottle may then be inverted in the funnel to serve as a fountain. A cluster of ampules may be held together by means of a rubber band. They may be kept in this manner for some time in the stockroom for replacement purposes if covered with a small piece of polyethylene sheet and wooden block.

Special provision should be made for organic solvents because of their low surface tension. One method is to insert small plugs of glass wool in the openings of the ampules to lessen the flow. It may be wiser, perhaps, to substitute bottles in these cases because of their larger mouths. They are also desirable where larger quantities of solution are called for. If bottles are used, they should be of the flat type and of uniform length equal to that of the ampules.

The structure of the rack permits both built-in ringstands and test-tube racks. The tray on the top may be used to hold solids either in small bottles or in the newly-developed packaged form.

The rack may be used on ordinary tables in crowded laboratory space. With the small quantities of reagents used in semi-micro chemistry, alcohol lamps are sufficient for a source of heat. For the water supply, quart bottles with siphons may be mounted in the tray on the top of the rack. This same source of water may be used as a coolant in distillations especially if the cold finger type of apparatus is used.



This is the *Chem-Racks* Combination Holder and Closure for Containers (Patent No. 2,710,694).

General

A Holiday Matching Test

By ROBERT SILBER
Central High School, Evansville, Indiana

Faced with the problem of keeping students attentive on the day before a holiday, I sought something which would carry out the pre-holiday spirit yet also permit learning to take place. My solution is a matching test which, if answered correctly, spells out a holiday greeting.

The first time I used such a test, which I devised myself, it was given without warning. Shocked by the idea of a test on the last day before a holiday, none of the students noticed the words spelled out by the answers until the tests were graded in class. Then they made many favorable comments and agreed they had learned from the test while having fun doing it. The tests, of course, were not counted gradewise.

My suggestion is, if you teach more than one class in the same subject, ask the students in the first class to keep your secret. Tell them to warn their fellow students a test is coming but not what its character is. This will start hurried studying but the students will later enjoy having taken part in the secret.

As a sample, here is a Chemistry Matching Test. For each numbered fact in the right-hand column, find the correct answer in the alphabetized left-hand column. Then place the identifying letter of the alphabet in the blank space before the numbered fact. (Answer on page 369.)

A. Proton
B. Gamma rays
C. Tritium
D. Oxygen
E. Krypton
F. Beta rays
G. Isotopes
H. Electron
I. Atomic weight
J. Edward Teller
K. Einstein
L. Carbon
M. Molecule
N. Cyclotron
O. None of these
P. Hydrogen
Q. Alpha rays
R. Heavy water
S. Marie Curie
T. Atomic number
U. Deuterium
V. Pitch blende
W. John Dalton
X. Theory
Y. Nucleus
Z. G. N. Lewis

.... 1. A negatively charged particle found in the atom
.... 2. A positively charged particle found in the atom
.... 3. Has an atomic weight of 1
.... 4. Has an atomic number of 1
.... 5. The central, dense part of an atom
.... 6. The number of protons in the nucleus of an atom
.... 7. It circles the nucleus of an atom in orbits
.... 8. It weighs $\frac{1845}{1846}$ as much as a hydrogen atom
.... 9. Commonly called an atom-smasher
........10. Developed the formula $E = Mc^2$
........11. Discovered radium
........12. Forms of the same element whose atoms differ only in weight
........13. That number which represents the weight of an atom when compared to the weight of the oxygen atom as 16
........14. A mineral containing uranium from which radium can also be extracted
........15. The number of protons plus the number of neutrons gives us the ....
........16. Dr. E. O. Lawrence invented this instrument
........17. Some elements have different forms. If the forms have the same chemical properties, but different atomic weights, they are called ....

Have you a Classroom Idea that you want to share with other teachers? If you think it's a practical idea, and one that you've not seen reported in these pages, write it up for us. Photographs (glossy prints) or diagrams (in India ink) which illustrate your Idea are wanted, too. We have a file of Classroom Ideas but we're constantly on the search for more. *Send yours in.*

—The Editor

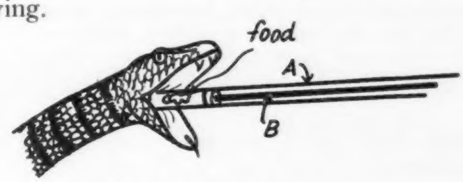
Biology

Force Feeding Snakes

By THOMAS P. BENNETT
Florida State University, Tallahassee

When snakes are maintained in the laboratory for any length of time, it becomes necessary to feed them by force since many snakes refuse to eat voluntarily. The following method has been found highly effective and can be carried out very easily in any laboratory.

The apparatus was set up as shown in the drawing.



A piece of glass tubing with about the same outside diameter as that of the snake's mouth was drawn out slightly and fire polished. A solid glass rod (B) or wooden dowel was fitted to the inside of the tube (A) but with sufficient room left to allow free movement of the rod in the tube.

To force feed a snake, one inserts food in the tube. The fire-polished end of the tube is then inserted in the snake's mouth. The rod is used to slowly force the food from the tube into the snake's mouth and down its throat.

For Biology Teachers: Now in the planning stage is an eight-week summer writing conference, which will develop a sourcebook of laboratory and field studies in secondary school biology courses. The group will consist of 20 high school teachers and ten college and university biologists. The conference will take place June 24 to August 16, 1957 at Michigan State University, East Lansing. Each participant will receive a stipend of $1000; round-trip travel expenses will be paid. The deadline for applications is January 31, 1957. Write to: Committee on Educational Policies, Division of Biology and Agriculture, National Research Council, 2101 Constitution Ave., N.W., Washington 25, D. C. This group and Michigan State University are sponsoring the project with grants from the National Science Foundation.

NSTA Activities

Suggestions Wanted

The committee on election of officers and directors for 1957-58 will meet early in December to draw up a slate of nominees. The committee earnestly requests all interested NSTA members to send in suggestions for the various offices to be filled. Please write directly to the chairman of the committee, Miss Madeline Skirven, 2900 Ailsa Avenue, Baltimore 14, Maryland.

Offices and positions for which nominees must be chosen include president-elect (to be president in 1958-59), secretary, treasurer, and regional directors for regions I, III, V, and VII. When writing, please give full name, position, and address of suggested nominee, the NSTA position for which the nominee is suggested, and a brief biography including professional interests and activities. In its slate of nominees, the committee will seek to provide representation of all of NSTA's concerns and activities ranging from elementary school through junior and senior high and including the college level, and cutting across all fields of science.

Northeastern Conference

Perhaps the first official act of NSTA president-elect Glenn O. Blough was to appoint a committee to plan a northeastern regional conference authorized by the Board of Directors last summer. The conference is scheduled to be held October 18-19, 1957, in the Statler Hotel, Hartford, Connecticut. Fred McKone of Teachers College of Connecticut at New Britain has been named general chairman for the conference which will be co-sponsored by NSTA affiliated groups within the region. More information about the conference will soon be forthcoming, of course, but now is not too early to mark this date on your calendar.

New York City Meeting

The eighth annual joint meeting of the science teaching societies affiliated with the AAAS will this year be held at the Sheraton-McAlpin Hotel in New York City, December 26-30. As usual, an attractive program has been arranged. Early arrivals will have the opportunity of taking an NSTA-sponsored field trip to Macy's Bureau of Standards and to "behind-the-scenes" operations of the city's subway system. The trip is scheduled for the morning of Wednesday, December 26. After dinner the same day, the New York chapter of the Business-Industry Section of NSTA will play host to members of all the societies at a dance and mixer.

General meetings will be held each day, arranged either by one of the individual societies or the AAAS itself. Individual sessions of NSTA will convene on the mornings of Friday and Saturday, December 28 and 29. This year NABT has assumed responsibility for the elementary science program. Other cooperating societies are ANSS and NARST.

Local host for the meeting is the Federation of Science Teacher Associations of New York City. General coordinator is J. Darrell Barnard of New York University; NSTA chairman is Alfred D. Beck, one of New York City's science supervisors.

STAR Awards

Less than two months remain in which to submit your entry in the STAR awards program (see page 251, September *TST*). Participation in this program is doubled-edged: first, you run the risk of winning a $200 cash award or a three-day, all-expense trip to Washington, D. C.; second, you render a real service to the science teaching profession since *all* of the entries will be considered for inclusion in the publication to be based upon the program. A booklet of selected STAR science teaching ideas will be printed and widely distributed. Remember: *closing date is December 21, 1956;* also, submit *two* typed copies of your entry.

Tomorrow's Scientists

Probably by now you have received your copy of the first issue of the NSTA's new publication for science students. How did your students like it? How many entered subscriptions? Have you sent in your order for five *(the minimum)* or more subscriptions to the remaining issues in 1956-57? Your cooperation and that of your students is needed to make *Tomorrow's Scientists* a success. Use it, criticize it, suggest improvements, send in contributions. This paper is to be for students and, largely, by students. We look forward to at least one more issue before Christmas and at least four issues during the winter and spring months. So send in those subscriptions; at least 5000 are needed to keep the paper going. (Confidentially, though, we are expecting at least 12,000 subscriptions in this month alone.)

5TH NATIONAL CONVENTION OF NSTA

CLEVELAND, OHIO — MARCH 20-23, 1957

March 1957 is just around the time-corner for the members of the NSTA General Planning Committee for the 5th National NSTA Convention. Setting the dates: March 20-23, 1957, and the place: the Hotel Cleveland, Cleveland, Ohio, were but the first major actions. Selecting the convention theme was another important step: *New Frontiers for Science Teachers.* Now, each day, the committee members are working out the many details that must be geared together for another smoothly-running and successful convention: lining up speakers of significance, panel members, and moderators; setting up time schedules; checking reservations; making transportation arrangements.

The general program outline for the convention appeared on page 246 of the September 1956 issue of *The Science Teacher.* Here are more highlights as worked out to date by the committee.

The second day's session—Thursday, March 21—has been re-programmed. Instead of three major addresses that day, there will be one in the morning on the theme, *Impact of Science on Society.* The talk will be followed by three concurrent panels on "Implications for Science Teaching" in the elementary grades, one to six; the junior high grades, seven to nine; and the senior high and junior college grades, ten to 14. Following Thursday's luncheon, afternoon tours are being scheduled.

As was the case at the Washington convention last spring, the tours will be a major attraction at the meeting. Going into Cleveland schools and institutions and into industrial establishments, the tours will tie in with and contribute to the development of the convention theme. The tour program is being worked out by one of about a dozen local committees, made up of some 80 teachers from Cleveland and the surrounding area, already at work on their assignments.

Thursday evening's after-dinner session will be the annual Hospitality Night. This year it will take the form of a reception by the NSTA Board of Directors.

Friday night's annual banquet will present a distinguished speaker: the widely-known geneticist, Laurence Snyder. Dean of the Graduate School of the University of Oklahoma, Dr. Snyder will be president of the American Association for the Advancement of Science at the time of the convention.

Another of the sessions' outstanding speakers will appear on Saturday afternoon's elementary science program. He is Paul R. Young and he will discuss the unique and world-renowned garden education program of the Cleveland schools.

One important part of pre-convention planning is going on behind-the-scenes at NSTA headquarters. Now being readied are the advance registration forms and hotel reservation cards which will go out to all NSTA members in January. Everyone who possibly can is urged to fill out and return these forms and cards immediately. Prompt replies will make it that much easier for the committee to firm up details for a "smooth" convention.

One idea that science teachers might begin to explore and develop now in their own communities is that of using scientists as substitutes for teachers who wish to attend the convention. For the Washington convention last March, more than 2000 government and industrial scientists in the area volunteered to teach a day or so to enable teachers to attend. About 800 scientists actually were used over the three-day period, and about 400 teachers were thus provided free time without loss of pay or the necessity of Boards of Education hiring substitutes (who weren't available anyway). At least 100 additional teachers attended the convention through the same kind of participation back in their home communities, and several were sent to the convention as guests of an industrial company with all expenses paid.

It's a *good* idea! Teachers can spark the idea, but, of course, it should be worked out carefully with full cooperation of administrative authorities of the school and with responsible representatives of the scientific fraternity in each community. It would be appreciated, incidentally, if all teachers will keep the NSTA headquarters office informed of plans and successes along this line.

In session in Cleveland this fall, members of the Fifth National Convention planning committee took a few minutes off to pose for the photographer. Pictured here, seated, left to right, are: Dorothy Alfke, Mrs. Grace Maddux, Dorothy Tryon, Mrs. M. Gordon Brown; standing: Arthur O. Baker, Chester A. Lawson, James G. Harlow, John S. Richardson, Robert H. Carleton, James H. Misch (assistant chairman for local arrangements), Herbert Reichard. Unable to attend the meeting was Ellsworth S. Obourn.

FSA Activities

More Sponsors

The roster of sponsors of the FSAF program continues to grow. Newcomers since the October *TST* listing include the following, which bring the total to 70 for 1956 and to nearly 100 since FSAF was organized in 1952.

The American Ceramic Society, Inc.
American Cyanamid Co.
Climax Foundation, Inc.
The Pittsburgh Plate Glass Foundation
West Virginia Pulp and Paper Co.

1956-57 Program

The fourth annual conference of FSAF sponsors, advisers, and administrative committee was held in Washington, D. C. on October 3 and 4. Important, perhaps history-making, decisions call for the following actions for the 1956-57 Foundation program.

1. Discontinue the student chart-making contest.
2. Continue "catalytic efforts" to help provide summer employment of science teachers in science-related jobs and as research assistants in universities.
3. Continue publication of revised editions of *Careers in Science Teaching* and *Encouraging Future Scientists: Keys to Careers.*
4. Continue co-sponsoring and conducting summer conferences for science teachers, with the special feature of "a report to the profession" to be developed by each conference.
5. Continue the ASM program of Science Achievement Awards for Students.
6. Carry out a research study and publish a monograph on policies, practices, and problems in the summer employment of science teachers in industry.
7. Develop and publish a booklet on *Encouraging Future Scientists: Ways Industry Can Cooperate.*
8. Develop plans for a student organization of Future Scientists of America, the final decision on same to be made at the spring meeting of the FSAF Administrative Committee. (This is in response to numerous requests or suggestions for such an organization by NSTA members.)
9. Develop plans for a fund from which grants can be made directly to teachers for "on the job" research dealing with various aspects of science teaching. It is felt that grants of a few hundred to a few thousand dollars made directly to classroom teachers would encourage and enable some productive study and tryouts of ideas. Examples might be any of the following. What are some effective techniques and devices for the early identification of students with scientific potential? What are some positive values to be gained from a "summer school" for capable, science-interested high school students? What is the effect of the school science fair on student enrollments in science courses? How can science career information and guidance materials be used effectively to help students better understand the nature of scientific work and the opportunities and rewards inherent in such endeavor, to the end that they are enabled to make wiser career choices? It is felt that a grants program of this kind should be supported by at least $50,000 a year and should be assured of a minimum run of five years.

SAA Box Score

The 1957 program of Science Achievement Awards for Students is well under way. Hundreds of requests for entry forms have poured into the NSTA office. The following tabulation reports on the numbers sent to teachers in the several regions through October 21.

Region I	281
Region II	1341
Region III	558
Region IV	309
Region V	671
Region VI	457
Region VII	310
Region VIII	326
Total	4253

When encouraging your students to participate in this nation-wide program of incentive awards, it is well to stress the following points.

1. Projects submitted must be the work of *individual* students; projects worked on jointly by two or more students cannot be considered.
2. The write-up or report is the sole basis for judging; the report may, of course, be accompanied by drawings or photographs which help clarify what was done and how. Reports should be kept to reasonable length, say, 1000-3000 words.
3. Entries must be sent to regional chairmen, *not to the NSTA office;* they must be *postmarked* not later than March 15, 1957 (mail early).
4. Mass entries from all students in a given class or classes are discouraged. It is more desirable to submit only the best ten to 25 per cent.

FISCHER—continued from page 331

use the following sort of test at the close of the lesson. Specimens of a species not observed in the field are passed out and the students place check marks next to the correct responses in the following quiz.

Quiz

I. Examine the needles and indicate which statement describes their tips.

a) The tips are pointed and needle-sharp.
b) The tips are blunt with rounded corners.
c) The tips are perfectly rounded.
d) The needles are notched at their tips.
e) The needles taper gradually to a point.

II. Examine the cross section of one of the needles and mark the statement that describes what you observe.

a) The shape of the needle is round and without sides.
b) The shape of the needle is two-sided and flat.
c) The shape of the needle is four-sided and square.
d) The shape of the needle is three-sided and triangular.
e) The shape of the needle is four-sided and diamond-shaped.

III. Look at the arrangement of the needles on the twig and select the statement that describes what you see.

a) Needles are scattered singly, like bristles on a bottle brush.
b) Needles are scattered but are grouped in bundles of two.
c) Needles are scattered but are grouped in bundles of three.
d) Needles are scattered but are grouped in bundles of four.
e) Needles are scattered but are grouped in bundles of five.

IV. Note the nature of the point of attachment where needles have fallen off the twig or are removed carefully. Which of the following descriptions applies?

a) The place of attachment is a slight projection.
b) The place of attachment is a round, flat scar.
c) The place of attachment is a slight depression.
d) The place of attachment is covered with pitch.
e) The place of attachment is not discernible.

This lesson on conifers comes just before the Christmas recess. I encourage the students to note what species of conifers they have in their homes and tell them to bring back small samples of any that puzzle them. In addition, I ask them to see how many species they can identify as they travel homeward. When it is time to dismiss, I give each student a Christmas card on the cover of which is a sprig of some conifer, and it is with evident enthusiasm that they identify their samples. We enjoy studying this way and I like to think that the things they learn will make them good teachers.

Answer to Chemistry Matching Test
(Page 361)
HAPPY THANKSGIVING

Book Reviews

SCIENCE IN YOUR LIFE and SCIENCE IN OUR WORLD. Herman and Nina Schneider. 314p., 346p. $2.28, $2.36. D. C. Heath and Co., Boston. 1955.

These texts are the fourth and fifth grade books in the new Heath Elementary Science Series. As with the rest of the series, the books are correlated to some extent with social studies topics commonly taught at the same grade levels. Thus, the fourth grade book has a section on hot and cold climates. The fifth grade book contains sections on conservation and growth of crops and livestock.

The books are well illustrated and contain numerous activities (called experiments in the series) that children will enjoy performing. A small number of the activities require a degree of technical skill uncommon among elementary school children—although they appear simple on first reading. Thus, a simple looking motor and a steam turbine in the grade four book could be made by no fourth grader observed by this reviewer. And several activities in the fifth grade book—particularly those describing how to build a weather station—are difficult to perform and unsatisfactory on completion.

There is a determined effort by the authors to describe only homemade equipment in the activities. In general, such an intention is laudable. But milk cartons, pencils, pins, and snap fasteners are suggested even when they are unsatisfactory for the particular activity.

The selection of content seems to suit the interests of the children at the grade levels intended. The science seemed accurate to this reviewer. The illustrations are well integrated with the text. The Heath Elementary Science Series is a valuable addition to the growing list of attractive and accurate science texts for elementary school children.

J. MYRON ATKIN
College of Education
University of Illinois
Champaign, Illinois

CONSERVING NATURAL RESOURCES. Shirley W. Allen. 347p. $5.50. McGraw-Hill Book Co., Inc., New York. 1955.

This text designed for introductory courses in conservation of natural resources covers all the usual aspects of conservation — soil, water, forests, grazing, recreation, wild-animal resources, and human powers as natural resources. The recreational aspects of conservation and the fishery resources are not as comprehensively covered as the soil, water, and mineral resources.

Being a one-authored text with the same treatment throughout, and a relatively short easy-to-read one, it is especially useful in beginning college classes and with students from a variety of fields of interest. Teachers especially will find it a fine synthesis of conservation, with equal attention given to the social, economic, and biological aspects. The need for government to help guide the discovery, use, and management of all of our resources is indicated throughout the text. The book is well illustrated and the selected references will serve as a fine reading list of the important writings in the field.

RICHARD L. WEAVER
University of Michigan
Ann Arbor, Michigan

WONDER WORLD OF MICROBES. Madeleine P. Grant. 160p. $2.75. Whittlesey House, McGraw-Hill Book Co., Inc., New York. 1956.

This is a story of microscopic organisms, both helpful and harmful. The book tells what they look like, where they may be found, how they may be grown, how they may be studied and identified, and why they are important to us. The author reports on the work of such scientists as Leeuwenhoek and Pasteur, and also on such recent activities as Dr. Salk's development of the polio vaccine and the operations of a UNICEF (United Nations International Children's Emergency Fund) mobile unit in Indonesia to fight yaws through use of penicillin.

The illustrations by Clifford N. Geary do much to add to the clarity of the material presented, and the suggested activities should serve to encourage many young people to explore the area of microbiology for themselves.

FLORENCE GARDNER
West Orange High School
West Orange, New Jersey

Books Received

ATOMIC ENERGY (The True Book About). E. C. Roberson and A. Radcliffe. 142p. $4.75. Philosophical Library, New York. 1956.

An illustrated report on how the existence of atoms was proved and what atoms are really like. The book also tells what happens when atoms explode and how the energy released in these explosions can be used in bombs or to drive trains, ships, airplanes, and electric generators.

MARS. Franklyn M. Branley. 148p. $2.50. Thomas Y. Crowell Co., New York. 1955.

The story of the planet Mars written in language for the layman. The author also surveys the potentialities of reaching Mars.

BETWEEN THE PLANETS. Fletcher G. Watson. 188p. $5.00. Harvard University Press, Cambridge, Mass. 1956 (Revised Edition).

A book for the interested layman and amateur astronomer as well as the student of astronomy. It gives detailed facts about the four types of small members of the solar

system: the asteroids, comets, meteors, and meteorites. A special appendix of 67 photographic plates adds a graphic report on these heavenly wanderers.

THE CRUST OF THE EARTH. Edited by Samuel Rapport and Helen Wright. 224p. 35¢. A Signet Key Book, published by the New American Library of World Literature, Inc., New York. 1955.

A paper-back collection of articles on various aspects of geology. It includes writings on the earth's physical past, present composition, and likely future in the universe and it explores the core of the earth, its mountains, lakes, oceans, and atmosphere.

JET TRANSPORTS. John Lewellen. 152p. $2.50. Thomas Y. Crowell Co., New York. 1955.

An illustrated summary of developments in and the future outlook for the jet transport age. Based on his own experience as a pilot, the author describes how jets fly, how they keep from getting lost even when flying "blind," the principles of their design, the function of the turbojet and turboprop, and the future of the rocket, the ramjet, and atomic-powered jets.

GUIDE TO THE STARS. Hector Macpherson. 144p. $2.75. Philosophical Library, New York. 1955 (Revised Edition).

A handbook on practical astronomy, including a history of astronomy to the present day. One of its special features shows the reader how to identify the constellations and name the most important individual stars.

HOW TIME IS MEASURED. Peter Hood. 64p. $2.75. Oxford University Press, New York. 1956.

An account of the various ways of time-keeping from early days to the present era of electronic time-keepers. Clocks, their history, and their mechanism are fully described and illustrated.

NEW WORLDS OF MODERN SCIENCE. Edited by Leonard Engel. 383p. 35¢. Dell Books, New York. 1956.

A paper-bound original anthology of articles on what modern science is doing, what scientists are interested in, and how they work.

THEY ALMOST MADE IT. Fred Reinfeld. 198p. $2.75. Thomas Y. Crowell Co., New York. 1956.

A readable introduction to some of our most useful inventions, including stories of the forgotten inventors who came heartbreakingly close to success. Each chapter points out the far-reaching changes brought about by the Industrial Revolution.

You Can Depend on the GENATRON

● *The MODERN Electrostatic Generator*

THE CAMBOSCO GENATRON serves not only for classical experiments in static electricity, but also for new and dramatic demonstrations that are not performable by any other means. It exemplifies a modern method of building up the tremendous high voltages required for atomic fission, for nuclear research, and for radiation therapy.

Entirely self-exciting, the GENATRON cracks into action at the snap of the switch—whose only function is that of starting the motor drive. No auxiliary charging method is employed. Hence, despite an output measured in hundreds of thousands of volts, no hazard is involved, for the operator or for the observers.

An Output of 250,000 Volts—or More!

THE CAMBOSCO GENATRON is designed to deliver, in normal operation, a discharge of the order of 250,000 volts. That figure, a conservative rating, is based on many trials conducted under average conditions. With ideal conditions, a potential difference of 400,000 volts has been achieved.

Modern Design— Sturdy construction and ever-dependable performance distinguish the GENATRON from all electrostatic devices hitherto available for demonstration work in Physics. This powerful, high-potential source, reflecting the benefits of extensive experience in electrostatic engineering, has absolutely nothing but purpose in common with the old fashioned static machine!

NO FRAGILE PARTS—Durability was a prime consideration in the design of the GENATRON which, with the exception of insulating members, is constructed entirely of metal.

The only part subject to deterioration is the charge-carrying belt, which is readily replaceable.

NO TRANSFER BODIES—In all conventional influence machines, whether of Holtz or Wimshurst type, electrical charges are collected and conveyed (from rotating plates to electrodes) by a system of "transfer bodies." Such bodies have always taken the form of metal brushes, rods, button disks or segments—each of which, inevitably, permits leakage of the very charge it is intended to carry, and thereby sharply limits the maximum output voltage.

It is a distinguishing difference of the GENATRON that electrical charges, conveyed by a non-metallic material, are established *directly upon the discharge terminal.* The attainable voltage accordingly depends only upon the geometry of that terminal and the dielectric strength of the medium by which it is surrounded.

Unique Features of the CamboscO Genatron

DISCHARGE TERMINAL Charges accumulate on, and discharge takes place from, the outer surface of a polished metal "sphere"—or, more accurately, an oblate spheroid.

The upper hemisphere is flattened at the pole to afford a horizontal support for such static accessories as must be insulated from ground. A built-in jack, at the center of that horizontal area, accepts a standard banana plug. Connections may thus be made to accessories located at a distance from the GENATRON.

CHARGE-CARRYING BELT To the terminal, charges are conveyed by an endless band of pure, live latex—a CamboscO development which has none of the shortcomings inherent in a belt with an overlap joint.

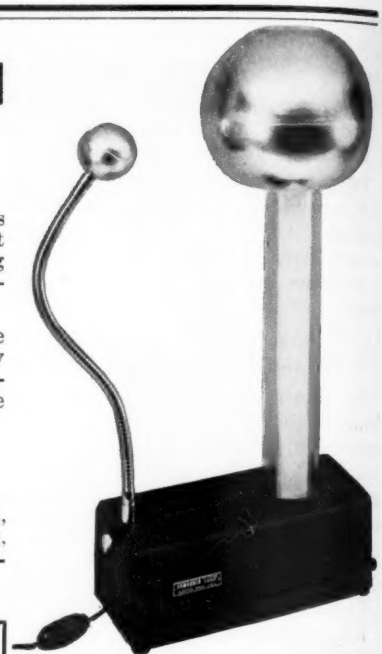
DISCHARGE BALL High voltage demonstrations often require a "spark gap" whose width can be varied without immobilizing either of the operator's hands.

That problem is ingeniously solved in the GENATRON, by mounting the discharge ball on a flexible shaft, which maintains any shape into which it is bent. Thus the discharge ball may be positioned at any desired distance (over a sixteen-inch range) from the discharge terminal.

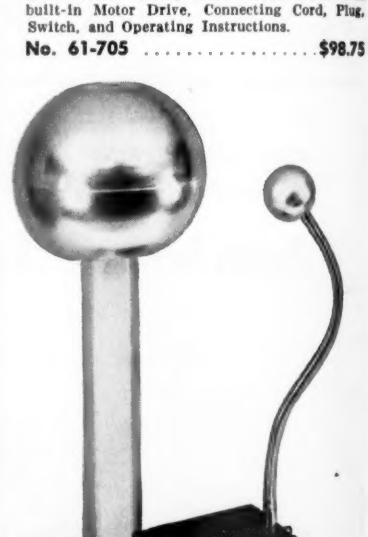
BASE ... AND DRIVING MECHANISM Stability is assured by the massive, cast metal base—where deep sockets are provided for the flexible shaft which carries the discharge ball, and for the lucite cylinder which supports, and insulates, the discharge terminal.

The flat, top surface of the base, (electrically speaking), represents the ground plane. Actual connection to ground is made through a conveniently located Jack-in-Head Binding Post. The base of the Genatron encloses, and electrically shields, the entire driving mechanism.

PRINCIPAL DIMENSIONS The overall height of the GENATRON is 31 in. Diameters of Discharge Ball and Terminal are, respectively, 3 in. and 10 in. The base measures 5¼ x 7 x 14 in.



GENATRON, WITH MOTOR DRIVE
Operates on 110-volt A.C. or 110-volt D.C. Includes: Discharge Terminal, Lucite Insulating Cylinder, Latex Charge-Carrying Belt, Discharge Ball with Flexible Shaft, Accessory and Ground Jacks, Cast Metal Base with built-in Motor Drive, Connecting Cord, Plug, Switch, and Operating Instructions.
No. 61-705 .... **$98.75**



GENATRON, WITH SPEED CONTROL
Includes (in addition to equipment itemized under No. 61-705) built-in Rheostat, for demonstrations requiring less than maximum output.
No. 61-708 .... **$109.00**

No. 61-710 Endless Belt. Of pure latex. For replacement in No. 61-705 or No. 61-708 .. **$3.00**

CAMBOSCO SCIENTIFIC COMPANY

37 ANTWERP ST. • BRIGHTON STATION • BOSTON, MASS.

Please mention THE SCIENCE TEACHER when you write.

Audio-Visual REVIEWS

Mrs. A. Mae Lukas, of the Jefferson County R-1 School System, Colorado, is the new chairman of the Film Preview Committee. This is the group which screens, evaluates, and recommends the curricular use of new films and filmstrips, and reports its recommendations in this column.

ROCKS AND MINERALS. 10 min. sound, 1955. $50 B & W, $100 Color. Film Associates, 10521 Santa Monica Blvd., Los Angeles 25, Calif.

Recommendation: Elementary and junior high school science and language arts areas.

Content: Depicting the formation of the three basically different kinds of rocks—igneous, sedimentary, and metamorphic—, the film identifies a variety of rocks and explains how they differ according to their substance. Particularly interesting is the process by which enormous heat and pressure, deep below the earth's surface, may gradually change either igneous or sedimentray rock into metamorphic rock.

Evaluation: Excellent photography and commentary. The color photography highlights the coloration due to mineral content present in some rock formations and dramatizes such scenes as a volcano in action.

LIFE ALONG THE WATERWAYS. 11 min. sound, 1955. $50 B & W (special order), $100 Color. Encyclopaedia Britannica Films, 1150 Wilmette Ave., Wilmette, Ill.

Recommendation: Upper elementary and junior high school grades in nature study areas.

Content: Depicting many forms of plant and animal life found near streams, rivers, ponds, and marshes, the film shows the dependence of these animals on the waterways, their activities and habitats throughout the seasons, and the relationships between these forms of plant and animal life. The alterations that take place along the waterways as they change from small streams to rivers are also presented.

Evaluation: Very good photography and commentary. The color photography highlights the natural beauty of the film's setting. A teacher's guide is available.

REPTILES. 14 min. sound, 1955. $62.50 B & W (special order), $125 Color. Encyclopaedia Britannica Films, 1150 Wilmette Ave., Wilmette, Ill.

Recommendation: Elementary and junior high school levels in nature study and science areas.

Content: Reporting on the five orders of reptiles remaining on earth, the film presents living sequences of lizards, turtles, tuataras, crocodilians, and serpents. The body characteristics of the various types of reptiles as well as the differences among them are shown. With photography by William Anderson, the film points out that all these animals have backbones, breathe through lungs, are cold-blooded, and have leathery, tough, and scaly skins.

Evaluation: A well-organized film with excellent color photography. The commentary is factual and is easily understandable at elementary grade levels.

THE HUMAN MACHINE. 14 min. sound, 1954. $55 B & W, $115 Color. Moody Institute of Science, 11428 Santa Monica Blvd., West Los Angeles 25, Calif.

Recommendation: Junior and senior high school and adult levels in science and biology areas.

Content: The precise and efficient workings of the human body and the machine-like way in which the parts of the body function together as interdependent systems are the subjects of this film. It explains the following systems with illustrations and discussions of their functions: the skeletal system, the coordinated muscular and skeletal system, the digestion and assimilation system, the nervous system, and the circulatory system. The film also demonstrates how these systems, constantly at work, make the body machine a living organism which can adjust itself to the many internal and external changes which it constantly experiences.

Evaluation: Very good commentary in a film with excellent instructional qualities. The special effects include animation, photomicroscopy, and X ray motion pictures. A teacher's guide comes with the film.

FIRST EXPERIMENTS ABOUT WEATHER. Filmstrip series, 6 titles. Color $27, individual filmstrip $4.75. Jam Handy Organization, 2821 Grand Blvd., Detroit 11, Mich.

Recommendation: Primary grades. Reading grade level varies from 2nd to 4th grades, but pictures can be used for demonstrative purposes in 2nd, 3rd, and 4th grades.

Content: The filmstrips present a series of simple experiments which will introduce primary grade children to the scientific method of problem solving. All the experiments can be carried out in an average classroom with the equipment at hand, and the children will see many different ways to find a single answer. The titles are: *What Is An Experiment, How Does Water Get Into the Air, What Makes Things Dry Faster, Where Do Clouds Come From, What Is Wind,* and *Why Is the Night Cooler Than the Day.*

Evaluation: Up-to-date and timely, with excellent photography and captions, the filmstrips are well organized in content and cover each topic effectively. The objectives are also very good. A manual accompanies the series and instructions to the teacher are included in the strips.

Activities of NSTA AFFILIATES

► The seven regional sections of the OHIO SCIENCE EDUCATION ASSOCIATION held meetings October 26. Dr. Conrad E. Ronneberg, of Oberlin College, was the main speaker at Central's session. Dr. Walter Warner, of Cincinnati, who recently served as an exchange teacher in Scotland, spoke to the Southwestern group. Ohio University's Dr. William G. Gambrel, Jr., addressed Southeastern's meeting and Val Salyer, of Monsanto Chemical Research Laboratories, spoke to the Western group. Northwestern's program was planned by the Toledo Edison Company and featured information on the Enrico Fermi power plant, the atomic-powered installation at Monroe, Michigan. Dr. Ellsworth S. Obourn, of the U. S. Office of Education, was the speaker at Eastern's session. Northeastern has already made plans for events in January, February, March, April, and May as well as for summer conference meetings. OSEA also reports that, under the presidency of Charles E. Hoel, of Columbus, the Association has sparked an increase of more than 70 per cent in NSTA membership in Ohio during the past two years.

► The Science Section of the ALABAMA EDUCATION ASSOCIATION has elected the following officers: president, John S. Martin, of Bessemer; vice-president, Margaret Nelson, Castleberry; and secretary-treasurer, Kathryn Boehmer, Birmingham. The group is planning an active program for the year.

► The NORFOLK COUNTY (Virginia) SCIENCE SUPPER CLUB presented its first award last month for "Distinguished Service to Science Education in Norfolk County." Recipient of the award was Dr. Mearl A. Kise, Director of Research and Development, Virginia Smelting Company, and president of the Hampton Roads Section of the American Chemical Society. Dr. Kise was cited for the assistance he has given to science teachers and students, through a science demonstration show he developed and has presented to area schools, through his participation in his company's two year-old program providing summer jobs for science teachers, through his speaking appearances at school science club and assembly programs, and through his efforts opening his company's facilities such as its reference library to science teachers and students. The Norfolk group established the award to express the appreciation of science teachers for public assistance and support. This year's officers of the Norfolk club are: president, Alan Mandell, of Portsmouth; vice-president, Moses Sheppard, Norfolk; and secretary-treasurer, Mrs. Nancy M. Witte, Portsmouth.

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